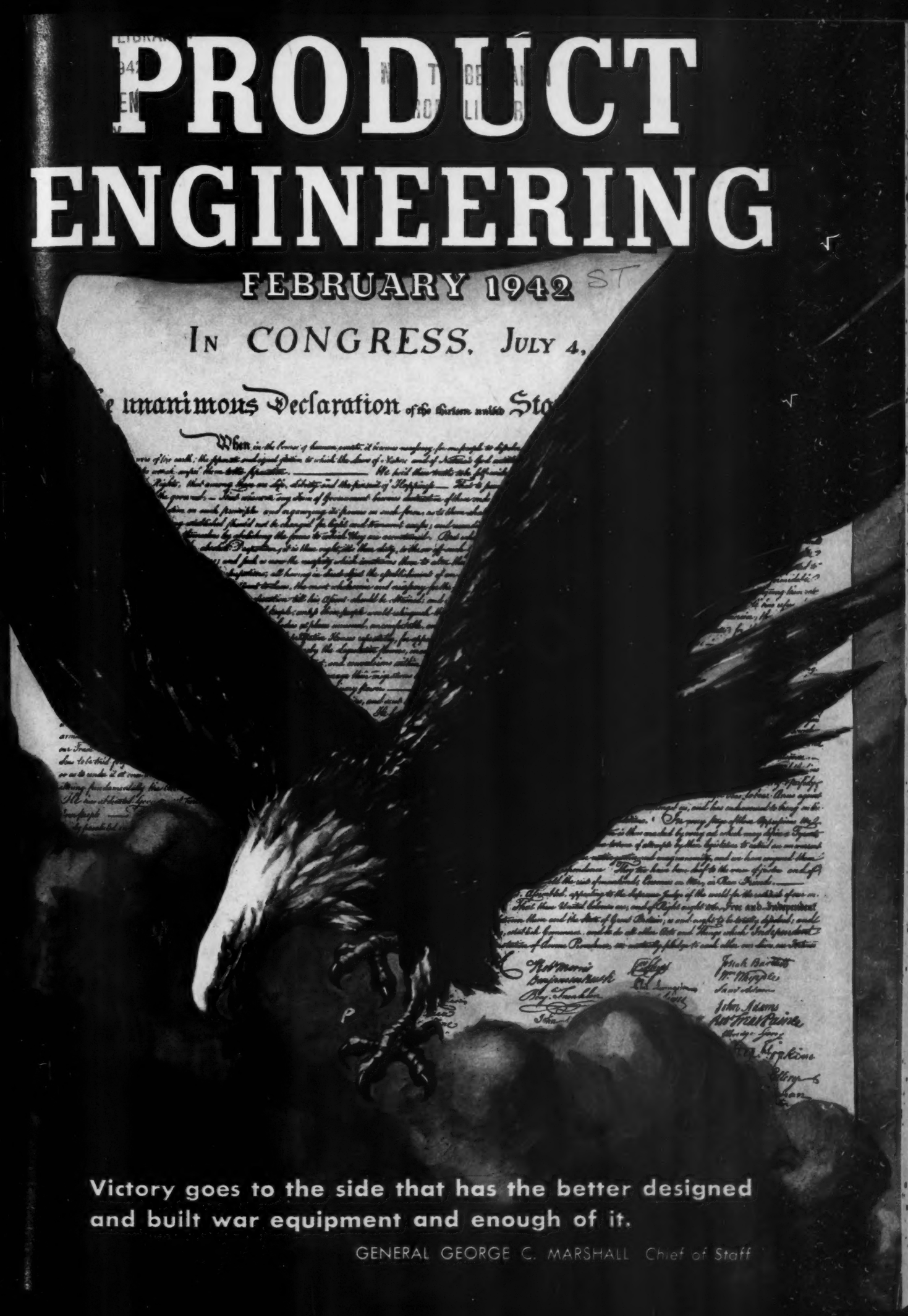
PRODUCT ENGINEERING

FEBRUARY 1942



Victory goes to the side that has the better designed and built war equipment and enough of it.

GENERAL GEORGE C. MARSHALL Chief of Staff

ALLOYS

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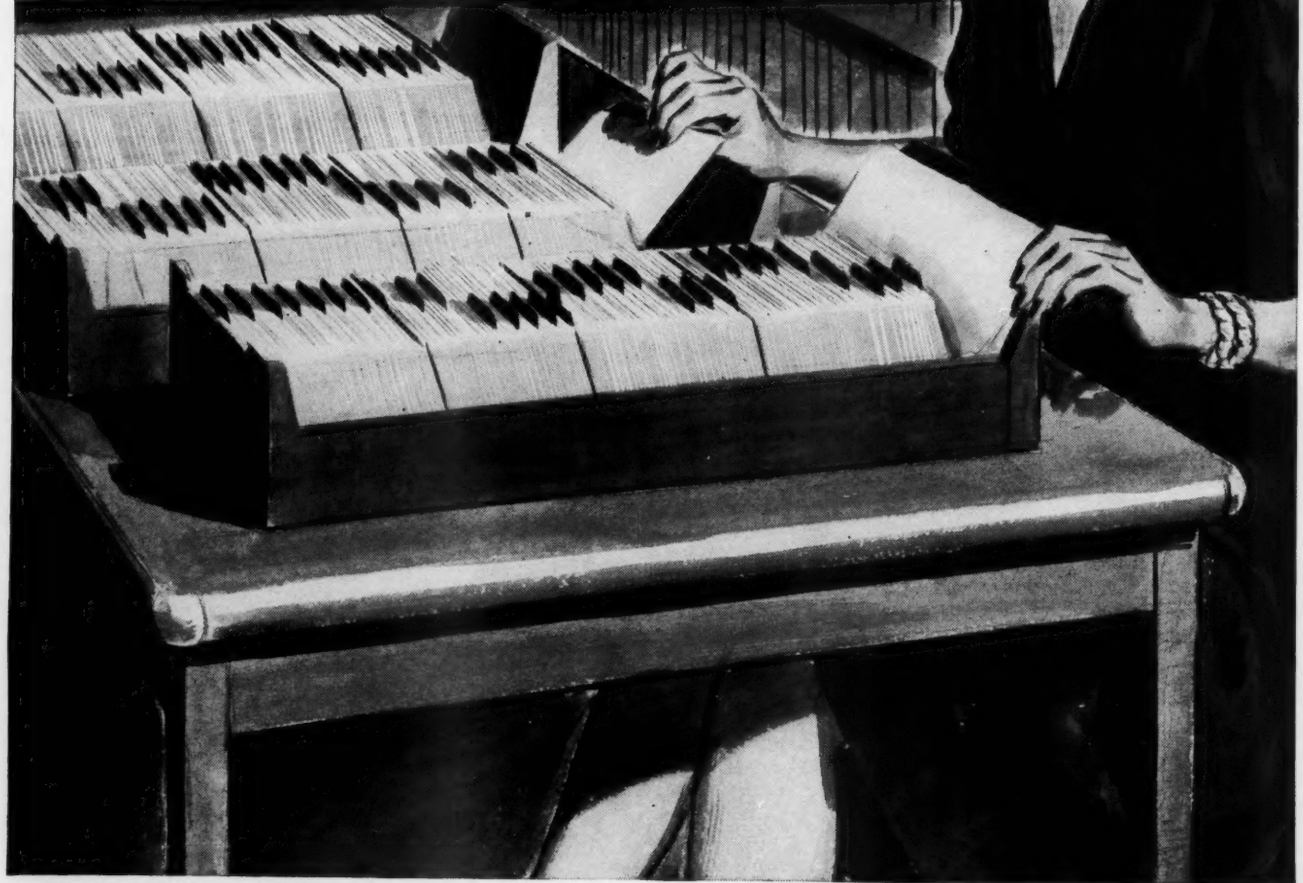

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IN THIS ISSUE

Vibration Control

Vibrations on the loose must be stopped before they reach machine frames, foundations, or buildings where they create noise, high fatigue stresses, or interfere with other equipment. Selecting flexible mountings to do this job is not guesswork—it is a good mathematical problem. Lead article this month gives all the facts, formulas and figures that should be applied, describes types of mountings, and suggests applications. Author: Leon Wallerstein, Jr., vibration engineer of Lord Manufacturing Company.

Aircraft Welding

Reference Book Sheet this month gives the formula for determining strength of fusion welded joints in aircraft tubing and sheet, and gives a nomograph for quickly finding the allowable load. A nomograph is also presented for quick determination of welding rod required. All this handy information is based upon Specification ANC-5, and is prepared by R. R. Wiese, former PRODUCT ENGINEERING western editor who is now with Fleetwings, Inc.

Time Delay Relays

Adding to the sketches presented last month in "Electrical Timing Devices," this month's mechanism spread presents a dozen more ideas for timing electrical circuits. Diagrams of circuits are given in a 3-page reference chart prepared by R. B. Immel of Westinghouse. Circuits are classified by types, length of intervals, accuracy, and other factors of importance to the product engineer.

Look Over Your Scrap Pile

"In Japan they put to good use all of the 32,000 ounces in a ton of steel. In contrast we are wasteful and extravagant," said Editor George Nordenholt in last month's editorial. But industry can no longer afford to be wasteful.

One of the best ways to save materials

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is to salvage worn or improperly machined parts. Salvage castings by welding. Redesign to eliminate inherent defects. Treat porous castings with plastics. Braze cracked castings. Build up worn or undersized parts by welding, metal spraying, or chromium plating. All these salvage methods are described on pages 78 to 80.

Toggle Design

If a toggle mechanism is improperly designed, its members may be far from overstressed and yet the frame may stretch enough to let the toggle snap over the center. When that happens it's a mighty tough job to pull the toggle back to where it belongs. Hans A. Illing, in an article beginning on page 68, presents the calculations required to design the toggle properly, and gives a convenient curve from which the necessary factors may be selected.

Materials Data

Common high brasses, cadmium coatings, mica conservation, carbon-molybdenum steels, and data on silver coated steels are covered in this month's special materials section beginning on page 102. Data on one group of common high brasses, which are the most popular brasses during peacetime, are part of the Wilkins-Bunn series. Since cadmium is a strategic material, the cadmium data sheet not only compares cadmium and galvanizing, but also tells how to find substitutes for cadmium.

Although deposits of mica in South America are of good quality, there is a definite shortage on this continent of skill and cheap labor to split the mica. See pages 97 to 99 for ways to avoid using high-grade mica-splittings by substituting lower grade mica.

Carbon-molybdenum steels, excellent in high-temperature service, are covered on pages 100 and 101. Data covers workability, properties and how moly content affects heat treatment.

Spring Steels

Last month, in Part I of this series by H. Carlson, PRODUCT ENGINEERING presented background information on steel and wire manufacture, and gave data comparing strength, properties, tolerances, etc., with specific data on hard-drawn steel spring wire.

"In This Issue" last month promised that the job would be finished with Part II this month. Sorry, but the article was longer than we had expected, and it is well worth dividing the remainder between this month and the March issue. Part II, page 89 of this issue, gives data on music wire and oil-tempered spring steels. Next month: chromium-vanadium and silicon-manganese steels.

Patent Procedure

If a product engineer has just developed a device, heavy machine or dime-store gadget, one of the first questions is: can he get a patent for it? Even before that is answered, another one pops up: what rights will his patent give him if he does get one? The answers to these questions cannot be completed without a lifetime's study, but Mr. Miles Henninger does a fundamental job in 3 pages, beginning on page 82, by explaining the nature of a patent.

Urea Plastics

Urea-formaldehyde resins today are just as hard to obtain for non-defense uses as any plastic material, but design planning and thinking is keeping an important place for them in defense designs now and in all designs for the future. If you are going to consider plastics in your products for good electrical properties or attractive color possibilities, read "Urea Plastics" beginning on page 93. Urea molding compounds, waterproof adhesives, plywood cements, and surface finishes are all covered. Dr. M. H. Bigelow, Plaskon, Inc., wrote the article.

F. B. I. Teaches

Hitler and the Japs are aching to get a glimpse of what's going on in American drafting rooms, so they have reached out with subversive, swastika-tattooed hands of espionage and sabotage to spy upon and disrupt American industry. Months ago the F. B. I. painstakingly began to teach industry how to guard itself, and emphasized protection of new designs, blueprints, and other confidential documents. Best protection methods, illustrated with anecdotes on how not to do it, are described on page 85. Author: J. Edgar Hoover.

Ceco—Seco

Leading Modern Designs for February are a Swiss-type precision screw machine and an automatic continuous-weigh coal scale. Principal design features of the screw machine are its independent variable-speed units. The coal scale is an excellent example of welded dust-tight housing construction. Coincidence: pronunciation of the names Ceco (screw machine) and Seco (coal scale).

WHAT'S COMING

Hydraulic Cylinders for Aircraft

Hydraulic actuating cylinders for aircraft are undoubtedly the most exacting of any hydraulic equipment. They are similar to hydraulic jacks in basic design, but there the similarity ceases. Chief limitations of weight and dimensions call for unique design details. Beginning next month, James E. Thompson and Rodney B. Campbell of Vultee Aircraft, Inc., will describe the factors involved, and will show how to develop both the estimated and detailed designs. Thompson, you may recall, was co-author of PRODUCT ENGINEERING's 1940-41 series on "Steel Tube Fuselages"—still much in demand—and he has a record for doing a complete job in his articles.

Acceleration-Sensitive Governors

Accurate centrifugal governors can regulate speed of a machine to within 0.05 percent, but the nature of the device makes it extremely difficult to eliminate hunting. If an inertia governor is added in combination with an ordinary centrifugal governor, the result will be close control of speed with no hunting. See March PRODUCT ENGINEERING for sketches of acceleration-sensitive governors and the theory.

Selenium Rectifiers

Nearly 90 percent of all metallic-junction rectifiers in use abroad are of the selenium type, latest figures indicate. In this country, with selenium available in unlimited quantities, production got off to a late start in 1938. Now selenium rectifiers are "going places" in industrial uses. Characteristics, applications, and data required for specific rectifier designs will be presented in March.

Heat-Resisting Varnishes

In order to increase the life and serviceability of coils in electrical apparatus, special impregnating varnishes have been developed. One type of such varnish will be discussed by L. E. Frost and Graham Lee Moses of Westinghouse in March P.E. Curves and test results will be included in the article.

PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

Every Design Engineer Can Help

ON THE COVER of this issue of PRODUCT ENGINEERING we quote General George C. Marshall, Army Chief of Staff, "Victory goes to the side that has the better designed and built war equipment and enough of it." No one can dispute this axiom. Ever since the invasion of Belgium and Holland, the power of superiority in quality and quantity of armaments has been demonstrated repeatedly. The above statement by our Army Chief of Staff merely emphasizes a fact that is generally recognized and thereby calls attention to the highly important part that the engineering talent in the United States must play in the winning of this war.

Developing war equipment that will be superior in performance is only a part of the designer's job. The speed and efficiency in manufacturing airplanes, guns, ships and mechanized equipment is determined largely by the designs developed. Quality of performance must not be sacrificed or even endangered but unnecessary accuracy and finish must be avoided. The materials used must be the best for the purpose but a scarce material should not be used where one less scarce will serve as well. Thus is the work of the designer of war materiel a controlling factor in the effectiveness and efficiency of the war effort and the speed of the Victory Program.

Design engineers not engaged directly in the development of war equipment might underrate the importance of their own work in its effect on the Victory Program. But by putting forth painstaking effort and using sound judgment, such as that which must be applied in the design of war equipment, every design engineer makes a distinct contribution to the winning of the war.

Every ounce of material and every minute counts. The designer who by carefully checking his calculations and drawings reduces the weight of material or man-hours required to produce a part, regardless of what the part may be, is contributing just that much material and that much man-power to the production of a gun, battleship or tank. So also is the designer who ingeniously alters the layout so that less scrap will be produced in the manufacturing operations or who finds a way to use a less scarce material. This is equally true whether the engineer be designing machine tools, power shovels, washing machines, vacuum sweepers, automobiles or any other machine or product that contributes to armaments or is essential to the nation's welfare.

In such ways and many other ways, design engineers everywhere are adding to the power of American industry to produce in superabundance better designed and better built war equipment. It is this power of American industry that will bring victory in the shortest time and with the least sacrifice. Every design engineer, regardless of his particular job, can contribute substantially to this power. If he cannot participate directly in the design of war equipment, he still can help by developing designs that will require a minimum of scarce material and the least equipment and man-hours to produce them.

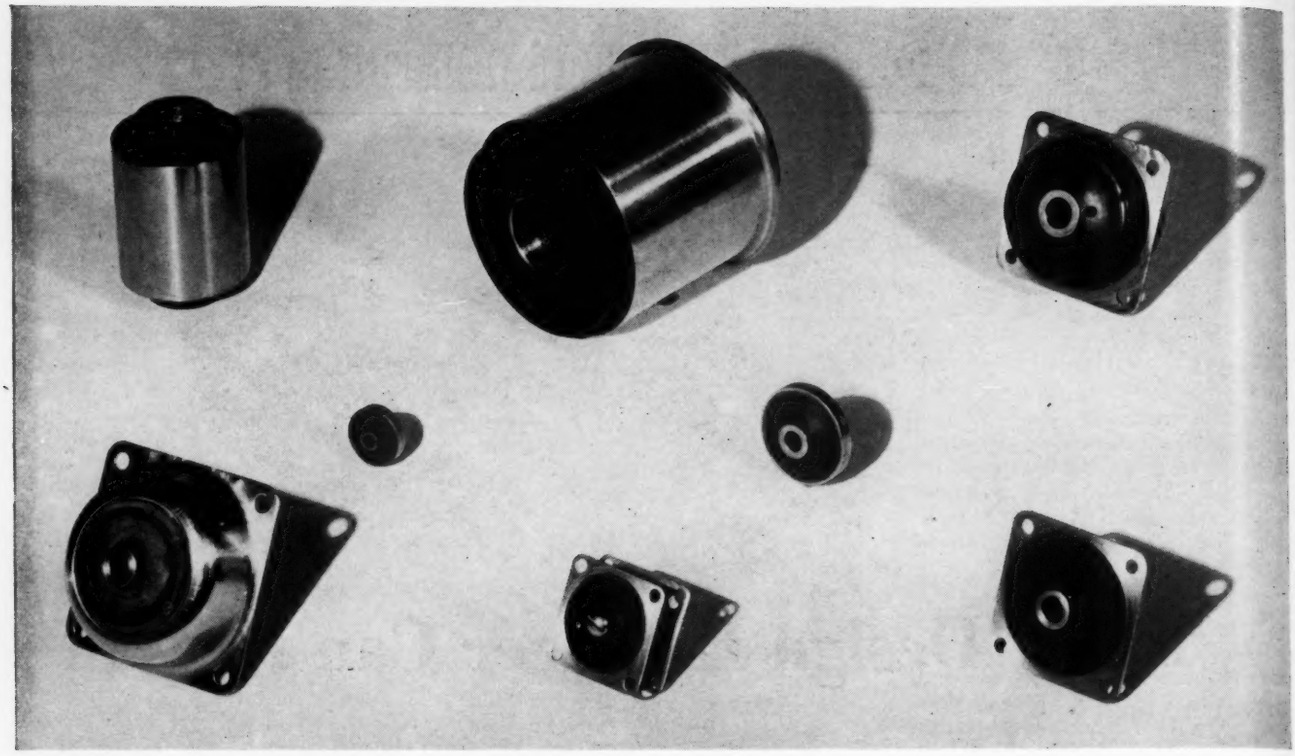


Plate form and tube form shear-type flexible rubber mountings designed to prevent the transfer of vibration to adjacent parts

VIBRATION CONTROL

By Means of Flexible Mountings

LEON WALLERSTEIN, JR.
Vibration Engineer, Lord Manufacturing Company

THREE METHODS of vibration control are available to the engineer, (1) mass balancing, (2) the use of tuned dynamic absorbers and (3) isolation by means of flexible mountings. Balancing eliminates a potential source of disturbance. Dynamic absorbers nullify existing vibratory forces by setting up equal and opposite forces. Flexible mountings prevent the transfer of existing vibration to adjacent parts.

No hard and fast rule can be stated to determine which form or forms of control should be selected for a given application, but a few general comments can be offered. Mass balancing, of course, is applied to some extent on almost every piece of rotating equipment. The effectiveness of this method is limited only by the degree of fineness to which the balance can economically be carried. Balancing cannot, however, combat vibration set up at frequencies other than the rotating speed of the balanced part nor from causes other than an initially unbalanced condition. It is not possible, for example, to eliminate the effect of torsional vibration from an internal combustion engine by mass balancing.

Tuned dynamic absorbers have a somewhat limited sphere of application. They are found primarily on constant speed devices involving unbalanced operation, and are also used in a specialized form for the purpose of reducing crankshaft vibration of internal combustion engines.

Flexible mountings, being suitable for variable speed operation, find almost unlimited use in eliminating the effects of vibration.

It is obvious that a vibratory force acting on a rigidly attached body is transmitted directly to the supporting foundation. It is also apparent that if the same force acts on a body floating in space, the force is resisted only by inertia of the body and that, as a result, the body will be accelerated through a small oscillatory motion. By supporting the body on its base with sufficiently soft springs the free condition can be approximated, so that a major portion of the vibratory force, being resisted by inertia of the floating mass, does not reach the base. The only alternating forces exerted on the support are caused by slight contractions and expansions of the spring in accommodating the movement of the body.

The degree of isolation obtained with a flexible mounting system can be expressed by an equation in which Transmissibility is the ratio of vibration

transmitted to that which would exist with solid attachment, F is the disturbing frequency, and f_n is the natural frequency of the mounted assembly.

$$\text{Transmissibility} = \frac{1}{\left(\frac{F}{f_n}\right)^2 - 1} \qquad (1)$$

To put this into words, for effective isolation the natural frequency f_n must be considerably lower than the disturbing frequency F. Specifically, F/f_n must be at least greater than the square root of 2. For values less than the square root of 2 magnification rather than reduction of vibration will occur and when disturbing and natural frequencies become equal, that is when F/f_n equals 1, resonance occurs with a great increase in transmitted forces. Continuous operation at or close to this ratio of the two frequencies must be avoided. If transmissibility is plotted against the frequency ratio F/f_n, the curve shown in Fig. 1 is obtained. From the curve it is clear that when the frequency ratio F/f is greater than the square root of 2 the vibration is reduced, and for values less than the square root of 2 the vibration transmitted is magnified.

The transmissibility equation applies for both translational and rotational vibration. Use of the equation requires calculating the natural frequency of the mounted assembly, or the natural frequencies, if more than one mode of vibration is present. Natural frequencies can be calculated from equations in which

k = translational stiffness of spring system in lb. per ft.
k_θ = rotational stiffness of spring system in lb. ft. per radian.
$m = W/g$ = mass in slugs
I = moment of inertia about the center of gravity in slugs-ft.^{2}
$\delta = 12\ W/k$ = static deflection in in.
W = weight in lb.
g = 32.2 ft. per sec.
f_n = natural frequency in cycles per min.

For pure translation

$$f_n = 9.55\sqrt{\frac{k}{m}} \qquad (2a)$$

This can also be expressed as

$$f_n = \frac{188}{\sqrt{\delta}} \qquad (2b)$$

For rotation

$$f_n = 9.55\sqrt{\frac{k_\theta}{I}} \qquad (3)$$

These equations are based on a mounting system the elastic center of which coincides with the center of gravity of the supported mass. Putting this another way, the equations apply when the mountings are so arranged that a pure couple acting on the supported body will cause rotation about its center of gravity and, conversely, a pure force applied at the center of gravity will cause translation without rotation. Variations from this condition will be discussed later.

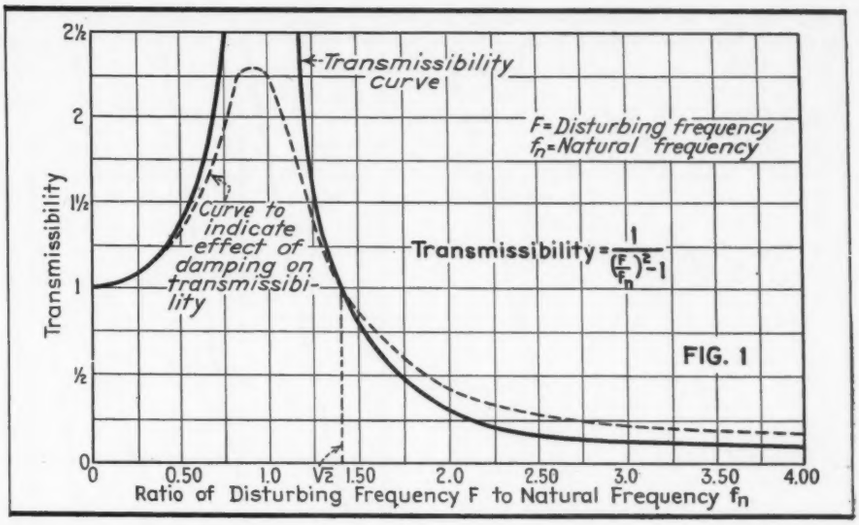


Fig. 1—Transmissibility curve which indicates the ratio of vibration transmitted by a flexible support to that which would exist with a solid support at various ratios of the disturbing frequency to the natural frequency

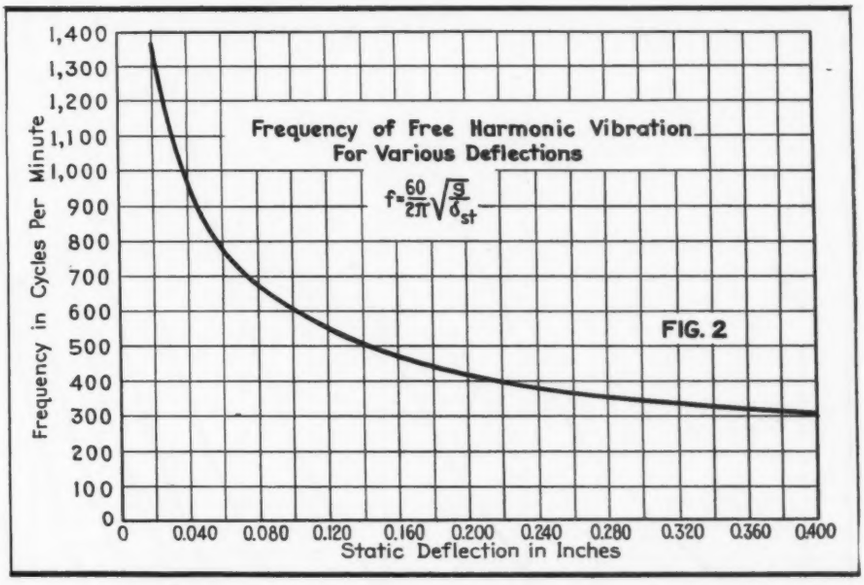


Fig. 2—Graph showing relationship between static deflection and natural frequency

The Transmissibility Equation (1) together with Equations (2*a* or *b*) and (3) confirm what instinct tells us, which is, that for a high degree of isolation soft springs are needed, giving a large static deflection and a low natural frequency. Equation (2*b*) is rather useful since it gives natural frequency directly in terms of static deflection. This is shown by the curve in Fig. 2.

For convenience in working with translational vibration, Equations (1) and (2*b*) have been combined into a series of curves as shown in Fig. 3, giving percent reduction of vibration for any combination of static deflection and disturbing frequency. Some comments may prove useful in applying these curves to flexible mounting designs.

The disturbing frequency F is generally the operating r.p.m. of the vibrating mechanism. If there are geared or belted parts, the lowest speed is usually taken.

The deflection must be considered with relation to the direction in which the vibrating force acts. In other words, if vibration is vertical δ is the vertical spring deflection caused by the weight

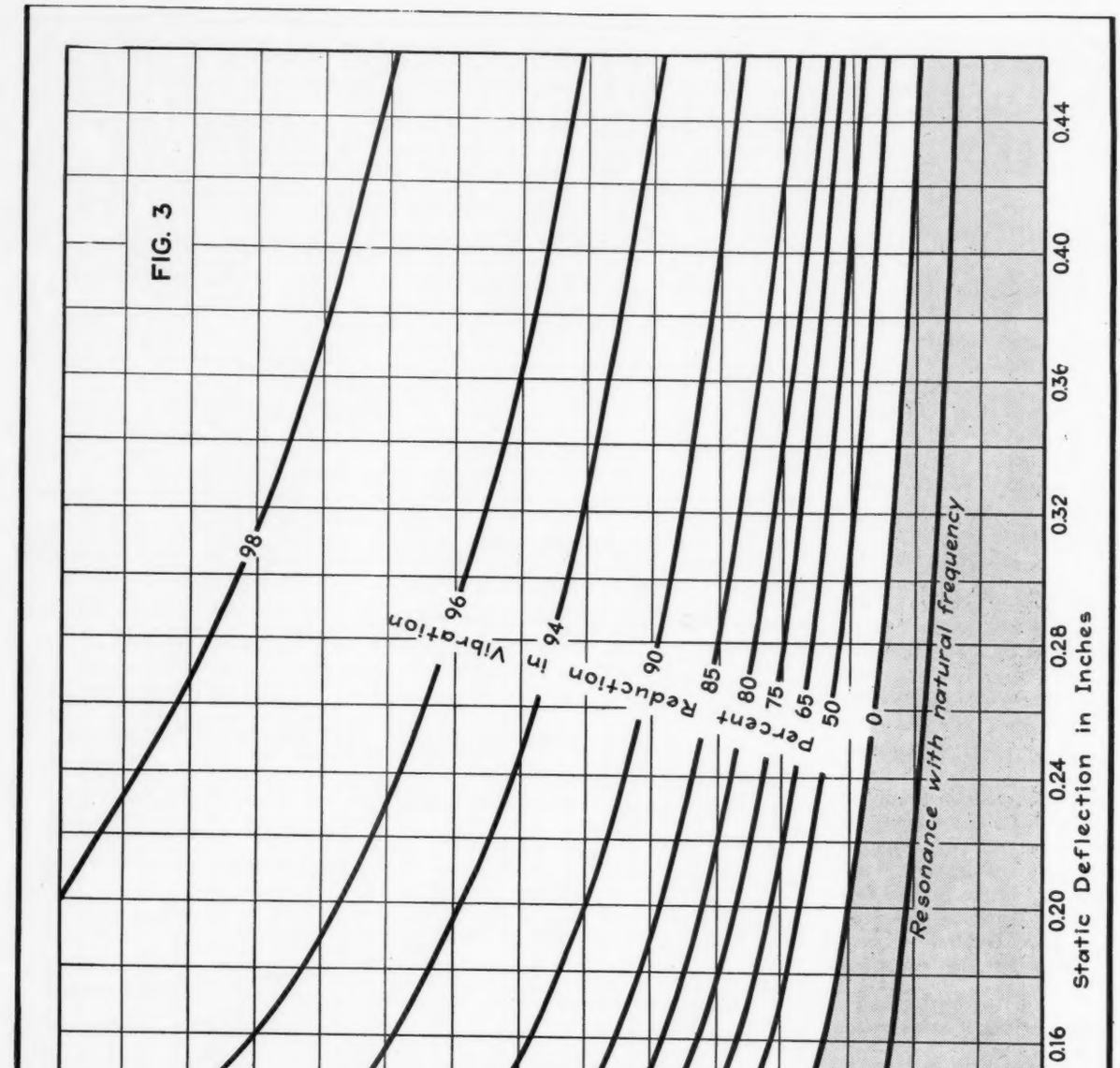


Fig. 3—Series of curves which indicate the vibration isolation efficiency for various combinations of static deflection and disturbing frequency and also region of magnification

of the body, but if vibration exists in a horizontal plane δ is the deflection which would occur if the weight acted horizontally instead of vertically.

The percent reduction to be provided by the system naturally depends on the intensity of the disturbance and the degree of protection required. Few installations are designed for less than 50 percent reduction. For mechanisms with large reciprocating forces or heavy power impulses about 75 percent or higher is desirable, and for protection of sensitive instruments and similar equipment even greater refinement is generally necessary.

It will be noted that in Fig. 3 the area below the zero percent reduction line is marked "Region of Magnification," and that it contains the curve of resonance where disturbing frequency becomes equal to the natural frequency of the system. Operation in this region without harmful effect is possible only if well away from the resonance point. This is mentioned because there may be both low and high frequency components of vibration in a single installation, and mountings which will provide effective reduction of the higher frequency disturbance may operate in the region of magnification with respect to the lower. Operation of this nature often represents a compromise between isolation and stability in installations where isolation for the lower disturbing frequency would require such a large static deflection that an extremely soft and unstable mounting system would result, whereas isolation for the higher frequency is both practical and desirable.

As an example, consider a portable engine driven compressor with the engine operating at 1,750 and the compressor at 400 r.p.m. If the entire outfit is carried on a common base and this is supported on mountings having $\frac{3}{16}$ in. vertical deflection under the total weight, it is found from Fig. 3 that in this direction a 94 percent reduction for vibration generated at engine speed is secured, but that the system is in almost exact resonance with compressor disturbances. By using still softer mountings a point could be reached at which isolation of compressor vibration would be provided, but it is seen that deflection greater than $\frac{1}{16}$ in. would be necessary to do this. On a portable unit this degree of flexibility might allow too much movement under road shock during transportation, therefore, stiffer mountings must be considered. On reducing the static deflection to $\frac{1}{16}$ in. it is found that reduction for primary engine disturbances is now 78 percent, but that the system is no longer near resonance with compressor disturbances, though they are still magnified slightly. From Equations (1) and (2*b*) the actual magnification is found to be 38 percent.

Installations can be separated into two main groups: In the first are installations in which the mounted unit is to be protected from vibration existing in the supporting structure; and in the second, installations in which vibration generated by the mounted unit is to be prevented from reaching surrounding areas. In installations of the first group, it is seldom necessary to calculate natural frequencies for rotational modes of vibration because vibration of the structure imposes only translational action on the mounted assembly, in which event the curves of Fig. 3 alone form an excellent basis for mounting selection.

In installations of the second group, not only the curves of Fig. 3 must be satisfied, but if rotational disturbances exist, the natural frequencies in rotation should be determined and substituted in Equation (1) to insure adequate isolation. In both groups of installation it is desirable to place the mountings as nearly as possible in a plane containing the center of gravity to permit maximum flexibility with minimum loss of stability. Fig. 4(*A*) illustrates such an arrangement, and Fig. 4(*B*) shows an arrangement in which the mountings are behind the center of gravity. In either arrangement horizontal vibration would cause only horizontal translation of the instrument. However, if a vertical disturbance were present in the supporting structure, both tipping and translation would result in the arrangement shown in Fig. 4(*B*), whereas in the arrangement shown in Fig. 4(*A*) only pure translation would result and the motion of the instrument would be much smaller. The arrangement shown in Fig. 4(*A*) is described as a "decoupled" suspension since rotational and translational modes can occur independently, whereas that shown in Fig. 4(*B*) is a "coupled" arrangement.

Decoupling is of particular value when the isolated body is part of a mobile installation that is subject to shocks and abnormal accelerations which would produce greater movement of the unit with the suspension shown in Fig. 4(*B*) than with a true center of gravity suspension. Examples of this are a flexibly mounted radio transmitter which is subject to severe road shocks, and the instrument panel or the engine of an airplane both of which are subjected to landing and aerodynamic shocks. It is also true that with symmetrical suspension of a vibrating body alternating couples produce only rotation about the center of gravity, so that no movement of the center of mass is experienced, thus translational reactions are avoided.

As an illustration, consider the mounting of radial aircraft engines. The first satisfactory system developed for this purpose employed shear type tube form mountings, shown in Fig. 7. These were installed with their axes tangent to a circle about the crankshaft center line and, due to the engine arrangement, in a plane considerably behind the c.g. of the power plant. This type of mounting is quite soft axially, that is, in the direction which stresses the rubber in shear, and comparatively stiff radially. The axial flexibility re-

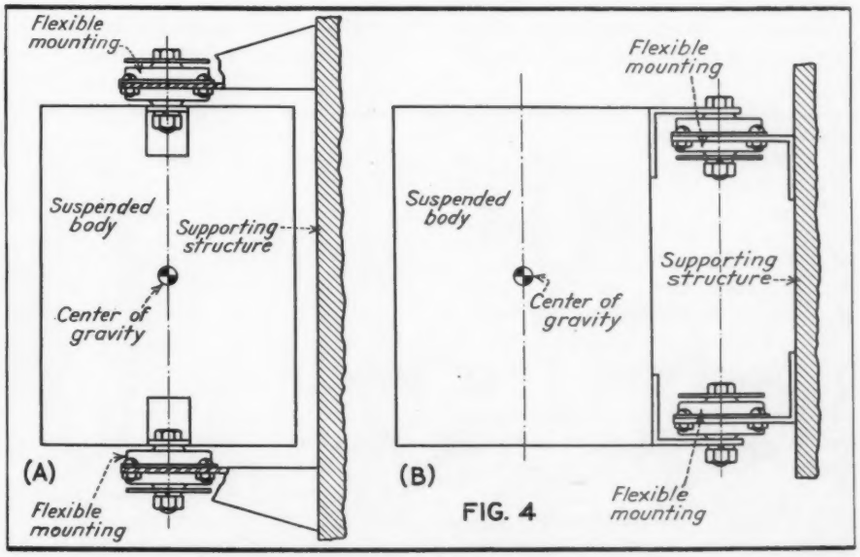


FIG. 4

Fig. 4—(A) Decoupled suspension, mountings are in the plane of the center of gravity of suspended body. (B) Coupled suspension, mountings are not in the plane of center of gravity of suspended body

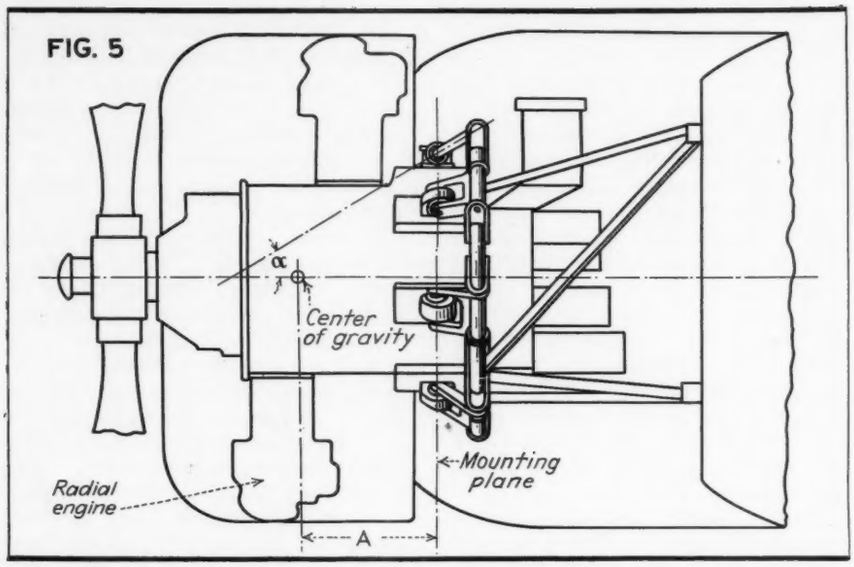


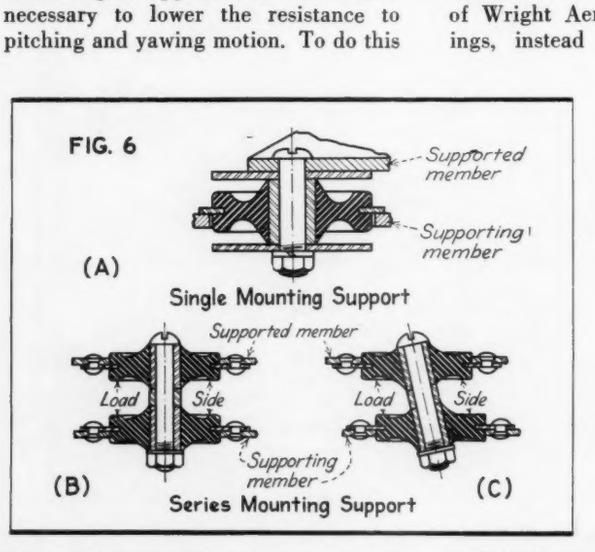
Fig. 5—Dynafocal suspension for radial aircraft engine. Mountings swung on links pointing a little ahead of the center of gravity provide an effective elastic center that coincides with the center of gravity at a distance "A" from the mounting plane

sulted in a sufficiently low natural frequency about the torque axis to provide a high degree of isolation for the torsional vibration generated by the engine. The overhang moment of the engine was resisted radially by the mountings which prevented excessive droop. The natural frequencies for rotation about axes perpendicular to the thrust axis, that is, pitch and yaw motions, were comparatively high so that should severe pitching or yawing couples have been present the isolation would not have been adequate. With the advent of higher horsepower engines with slow turning propellers, particularly the two-row radial engine, such couples appeared and it became necessary to lower the resistance to pitching and yawing motion. To do this by making the mounting softer radially would have accomplished the point, but would have resulted in so much droop as to cause excessive motion of the engine under landing and aerodynamic shocks.

A more satisfactory solution would have been to support the engine directly at the center of gravity so that the system could be made quite soft in all rotational modes, including pitch and yaw, without excessive loss of stability. This in effect was accomplished by a unique arrangement shown in Fig. 5, recently developed for radial aircraft engines, based on the ideas of Prof. E. S. Taylor of the Massachusetts Institute of Technology and K. A. Browne of Wright Aeronautical Corp. Mountings, instead of being attached directly to the airplane structure, are swung on links pointing a little ahead of the center of gravity of the engine. Any rotation about the center of gravity, pitch for example, causes swinging of the top and bottom links which offer little resistance. At the same time, the links being focused toward the center of gravity, fix this point relative to the supporting structure so that there is little instability even under considerable load.

It is not usually necessary to go to such extremes in order to obtain a center of gravity suspension, since the mounting plane can ordinarily be located at or close to the desired point. This example, however, illustrates the importance that correct mounting location can sometimes assume.

When explaining the significance of Equations (2*a*), (2*b*) and (3), it was stated that they applied only for a center of gravity suspension. Without symmetrical support, pure tranlational motion does not occur but appears as a tipping or rotational mode about some nodal point. Equations (2*a*) and (2*b*) are therefore not directly applicable. Equation (3) would be useful in designs that are without symmetrical support, provided the nodal points (there are two on any principal axis) which are set up at the resonant frequencies of the system could be ascertained. For then it would be possible to determine the body moments of inertia and the stiffness of the system about these nodes and apply them in Equation (3) to obtain the natural frequencies. Determination of these nodal points and corresponding natural frequencies is beyond the scope of this article. However, in an article by K. A. Browne entitled "Dynamic Suspension —A Method for Mounting Radial Aircraft Engines," in the May, 1939 S.A.E.



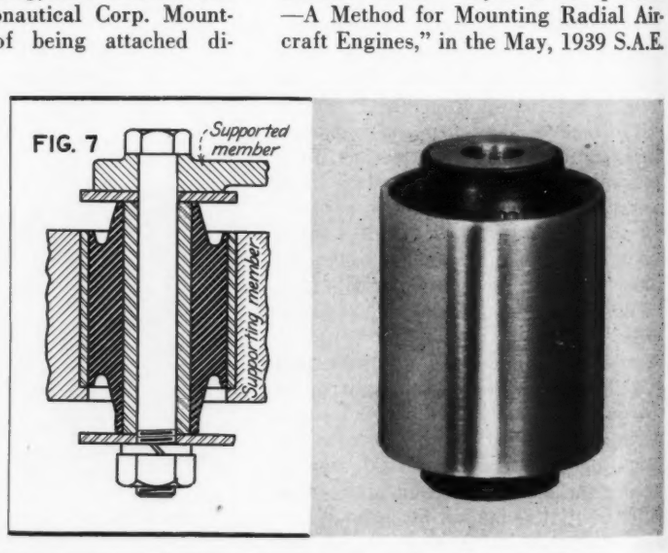


Fig. 6—(A) Plate form shear type mounting with single-mounting support. (B) Two plate form mountings in series for lateral as well as vertical flexibility. (C) Action of plate mountings in series under lateral load. Fig. 7—Tube form shear type mounting. This type and also the type shown in Fig. 6 are designed for axial loading which stresses the rubber in shear

Journal, they are worked out for a system in which the center of gravity is not in the mounting plane, and are plotted in the form of easily used curves.

Regardless of construction the chief requisite of a mounting is that it shall have the proper stiffness for the installation in question. Beyond that, form, material, and size are purely matters of convenience, durability and similar factors. Mountings are designed in a variety of shapes, sizes and materials. Steel springs and rubber springs are used for the majority of installations.

In comparing rubber versus steel springs, first and most important is the fact that rubber possesses sufficient damping within itself to "kill" quickly transient vibrations resulting from shocks or sudden impulses of any kind, and to reduce materially amplitudes of vibration when the system is passing through resonance. Second, rubber forms a complete cut-off against transmission of sound, whereas steel springs provide a metallic conducting path. Third, with steel springs alone limit stops for shocks or overload produce sharp metal to metal contact which may become annoying or be injurious to associated parts, unless cushioned by an auxiliary rubber bumper. Rubber mountings can incorporate cushioned restraint or snubbing within themselves. Fourth, steel springs require auxiliary guides for restraint against motion normal to their axes, whereas rubber shear springs form their own frictionless guides. Steel springs have the advantage of standing up under high temperature and in the presence of oil better than do rubber mountings, although some of the recently developed synthetic rubber substitutes are quite good on these counts. Probably the greatest usefulness for steel springs is where such extreme static deflection is required that a rubber mounting becomes excessively large and uneconomical. Very low speed machinery generally involves such conditions.

The use of rubber in shear is dictated primarily by the fact that its shear modulus of elasticity is lower than its tension or compression moduli and that, as a result, a given body of rubber formed to a reasonable shape will give greater deflection if the load is carried in shear. Large deflection could also be secured in compression if the rubber were formed for example into a tall, thin column, but such an arrangement would obviously be unstable. Furthermore, rubber can be deflected in shear to at least 30 percent of its thickness, and is sometimes used at a considerably higher value, as compared to a range of 15 to 20 percent maximum for compressive stress. Therefore, a much thicker compression type mounting is required to sustain a given deflection. Compression type mountings do offer one advantage in that they can bear higher unit loadings than rubber in shear. This characteristic can be put to good use where heavy loads are to be carried in a limited space and if frequencies are sufficiently high so that great flexibility is not necessary.

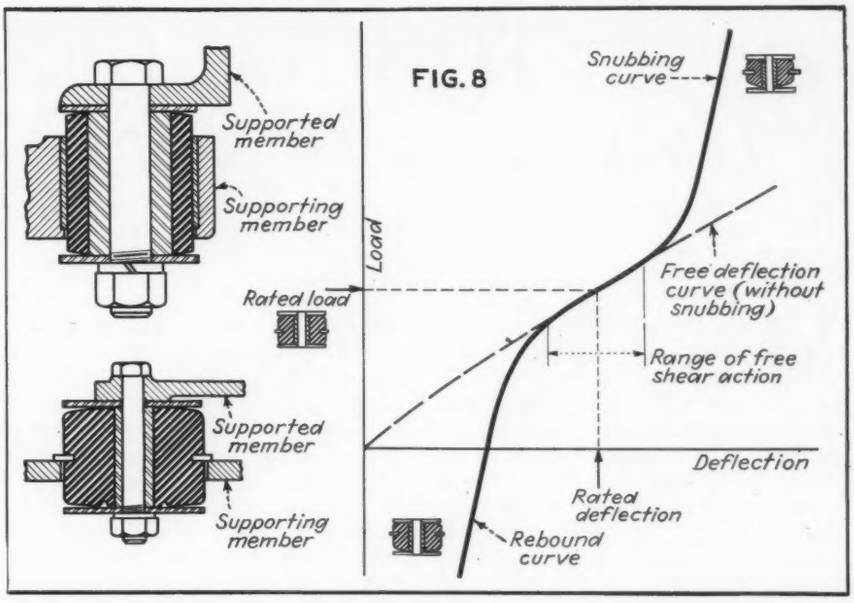


Fig. 8—Load-deflection curve for vertical snubbing mounting. Motion limiting features incorporated in the mountings impose no restriction on their normal action and thereby, the efficiency of the system as regards vibration isolation is unimpaired

Rubber in pure tension has not proved satisfactory as a load carrying material because it is highly sensitive to physical injury. Whereas unstretched rubber is comparatively difficult to cut, it is damaged easily when in tension and any defect will progress rapidly and cause quick failure of the part. In addition, the drift and set of rubber in tension is greater than under comparable loads of other types, and lastly, it is difficult to attach conveniently.

Shear-Type Mountings

An elementary form of shear type mounting is a sandwich of rubber bonded between two metal plates, a design which has proved useful within limits. The difficulty of safeguarding in the event of failure of the mounting, and the necessity for bolting both metal parts up solid before load can be applied, however, have been drawbacks to widespread adoption.

Two basic forms of shear-type mountings are shown in Figs. 6 and 7, being designated as Plate Form Shear Type Mountings and Tube Form Shear Type Mountings respectively. Both types are designed for axial loading, this being the direction of greatest resilience since the rubber is then stressed in shear. Radially the plate form mountings range from about 1¼ to 2¼ times as stiff as their axial spring rates. The tube form mountings range from extremes of about 4 to 12, depending on the size and proportions of the unit. This spread makes it possible to provide almost any combination of characteristics that may be necessary for a particular installation. Motion limiting features can be incorporated in both tube and plate form mountings by the use of washers at the ends of the center members to contact built up rubber shoulders under abnormal loading. As shown in Fig. 8, this imposes no restriction on normal action of the mountings so that efficiency of the system as regards vibration isolation is unimpaired.

Conditions sometimes arise under which severe vibration exists both along and perpendicular to the mounting axis, so that a high degree of lateral as well as axial flexibility is required. Two mountings placed in series as shown in Fig. 6 accomplish this quite neatly, and at the same time double the axial flexibility. By placing spacers of different lengths between the mountings, the lateral spring rate can be adjusted.

It is noteworthy that engineers in many fields are beginning to make vibration analysis as much a part of their design procedure as they do stress analysis. As a result, in almost all phases of industry and transportation the benefits of proper vibration control are being realized in improved life of equipment, in reduction of personnel fatigue and in increased comfort.

TOGGLE DESIGN

Calculations for Effects of Frame Deformation

HANS A. ILLING
The Hydraulic Press Manufacturing Company

MECHANISMS employing toggle joints are frequently used when it is necessary to produce a large force by the application of a comparatively small force. Fig. 1 illustrates a mechanism which serves to clamp two pieces, indicated by the shaded square. Fig. 2 shows a schematic drawing of a toggle joint and also a diagram of the forces involved. Q is the applied force. It is divided into two components, R (in the direction of the links), the horizontal component of which is the effective force P. The relation between P and Q is

$$\frac{P}{Q/2} = \cot a$$

or

$$P = Q\left(\frac{\cot a}{2}\right) \qquad (1)$$

The ratio between the applied force Q and the obtained force P depends on the angle "a" and any desired ratio appears possible with a compact design. This is the main advantage of the toggle mechanism. If some other device, such as a lever, is used, the ratio P/Q is a function of the dimensions of the lever. The lever must be long if a large value of P/Q is desired; in other words, compactness is sacrificed.

Though the toggle mechanism has desirable features, its design presents certain difficulties. The links may tend to go over "dead centers," meaning that the angle "a" goes through zero and becomes negative. Under such conditions the forces may be considerably higher than expected and the mechanism might be damaged by the resultant strain. Furthermore, it may take a force equal to the one originally applied to push the links back into their proper position. If there is no provision to apply such a force it might be nearly impossible to get the mechanism back into working condition. Obviously the danger that the links might go over "dead centers" is greater when the angle "a" is small to start with. On the other hand, since a small angle is desirable in order to obtain a large ratio, the accompanying design problem is well worth solving. It is the aim of this article to develop a method of designing toggle joints which will eliminate the danger of going over "dead centers."

A condition in which the links straighten out under load can be called "unstable" and is readily explained. Let it be assumed that a toggle joint has been set up with an angle "a" and that a force Q is applied. According to Equation (1) a force P may be expected on the frame. Under this load the frame will deflect a certain amount and the assumption may be made here that this deflection will not be large enough to allow the links to straighten out. This condition is apparently a stable one. The deflection of the frame, however, produces a decrease of the angle "a", resulting in a large force P_2 than expected. Of course, a larger force produces a larger deflection which in turn means a further decrease of the angle. The mechanism might or might not be stable and only by means of a mathematical analysis can this be decided.

In the graph, Fig. 3, the forces are shown as ordinates; the abscissa x represents the distance from the center to the end of the link (point E in Fig. 2). Let x_1 be the distance at which the toggle joint is supposed to work and let P_1 be the force expected. If point E moves to the right, due to deflection of the frame, the force obtained increases as shown by curve A. The force required to deflect the frame appears as a straight line, beginning at E_1 (provided that no part of the mechanism is stressed beyond the proportional limit). Assume that this straight line is the one marked B. The two lines A and B intersect and at the intersection the two forces are equal. To the left of this point the force P, obtained from the toggle mechanism, is larger than the resistance of the frame and causes point E to move to the right. However, to the right of the intersection the resistance is larger and forces the links back. This is a stable condition.

If the line D represents the resistance of the frame, the two lines, A and D, do not intersect and there is no stable position. Obviously, if the line of resistance is located in the shaded area, the mechanism will be unstable, the line C representing the border cases between stable and unstable conditions.

Referring to line B, the distance f

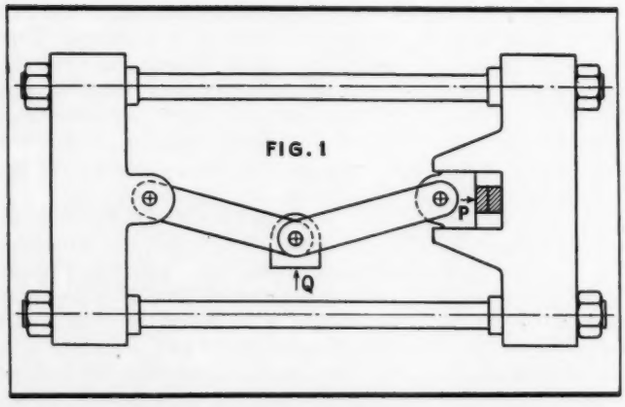


Fig. 1—Standard toggle joint design indicating acting and resultant forces. Acting force Q results in clamping force P

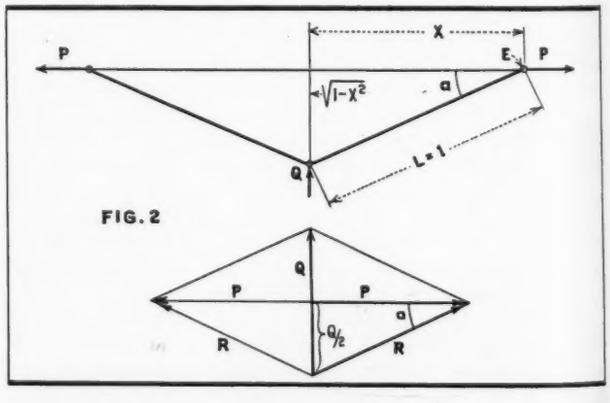


Fig. 2—Proportions and relations of the forces are shown in above drawing and vector diagram of a toggle joint

represents the deflection of the frame under the load P_1 and will be called "Expected Deflection." In reality the deflection will be larger, as represented by the distance F which we call "Actual Deflection." The mechanism will be stable provided f is smaller than f'. The latter will be called "Maximum Expected Deflection." In any specific case to be investigated, f can be calculated or found by experiment. If f' were known, a comparison of the two values would determine whether or not the mechanism is stable.

In order to find f', which of course is a function of the angle "a", it is necessary to develop first the equation of the curve A. For simplification it is assumed that the length of the links L is one inch and the force Q is one pound. Considering similar triangles in Fig. 2, the following is obtained

$$\frac{P}{1/2} = \frac{X}{\sqrt{1 - x^2}}$$

or

$$P = \frac{X}{2\sqrt{1 - X^2}} \qquad (2)$$

P is expressed as a function of x; in other words, Equation (2) is the equation of curve A. Required next is the equation of a tangent which goes through the given point E_1. The solution of this problem can be greatly simplified by assuming temporarily that the coordinates of the point of contact (x_2 and P_2) are known and x_1 is to be found. The equation of the tangent is then

$$y - P_2 = \frac{dp}{dx}(x - x_2) \qquad (3)$$

P can be expressed by means of Equation (1)

$$P_2 = \frac{X_2}{2\sqrt{1 - x_2^2}} \qquad (4)$$

$\frac{dP}{dx}$ is the derivative of Equation (2) and can be found as

$$\frac{dP}{dx} = \frac{1}{2(1 - x_2^2)\sqrt{1 - x_2^2}} \qquad (5)$$

By substituting Equations (4) and (5) in (3) the equation of the tangent is obtained

$$y - \frac{x_2}{2\sqrt{1 - x_2^2}} = \frac{1(x - x_2)}{2(1 - x_2^2)\sqrt{1 - x_2^2}} \qquad (6)$$

On this line one point is required for which

$$y = 0 \text{ and } x = x_1$$

Substituting these values

$$-\frac{x_2}{2\sqrt{1 - x_2^2}} = \frac{1(x - x_2)}{2(1 - x_2^2)\sqrt{1 - x_2^2}}$$

Simplifying gives the following

$$-x_2(1 - x_2^2) = (x_1 - x_2)$$

and

$$x_1 = x_2^3 \qquad (7a)$$

$$x_2 = 3\sqrt{x_1} \qquad (7b)$$

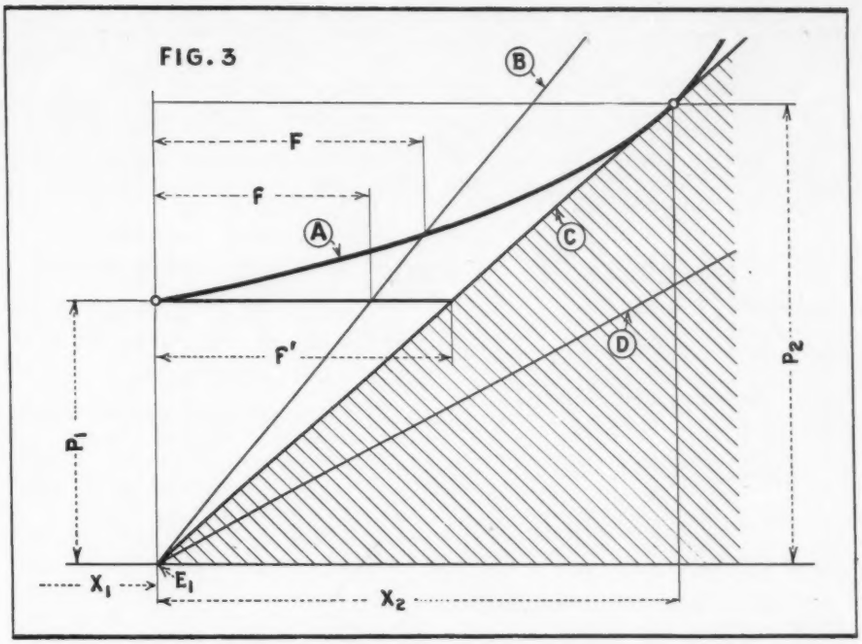


Fig. 3—If the frame's deflection extends into the shaded area the toggle will go over "dead centers" and will be difficult to get back into working position

Now f' may be found. Considering similar triangles in Fig. 3

$$\frac{f'}{P_1} = \frac{x_2 - x_1}{P_2}$$

or

$$f' = \frac{P_1}{P_2}(x_2 - x_1) \qquad (8)$$

The fraction $\frac{P_1}{P_2}$ is developed separately. Applying Equation (2)

$$\frac{P_1}{P_2} = \frac{\frac{x_1}{2\sqrt{1 - x_1^2}}}{\frac{x_2}{2\sqrt{1 - x_2^2}}} = \frac{x_1\sqrt{1 - x_2^2}}{x_2\sqrt{1 - x_1^2}}$$

Replacing x_1 by x_2, employing Equation (7a)

$$\frac{P_1}{P_2} = \frac{x_2^3\sqrt{1 - x_2^2}}{x_2\sqrt{1 - x_2^6}} = x_2^2\sqrt{\frac{1 - x_2^2}{1 - x_2^6}}$$

Since $\frac{1 - n^3}{1 - n} = 1 + n + n^2$ (n being x^2)

$$\frac{P_1}{P_2} = \frac{x_2^2}{\sqrt{1 + x_2^2 + x_2^4}}$$

Dividing numerator and denominator by x_2^2

$$\frac{P_1}{P_2} = \frac{1}{\sqrt{\frac{1}{x_2^4} + \frac{1}{x_2^2} + 1}} \qquad (9)$$

It is now possible to determine the values which will actually be obtained from Equation (9). As can be seen on Fig. 2

$$x = \cos a \qquad (10)$$

The largest value of "a" which must be considered is 26° 34′, since for this angle P equals Q. For any larger angle P is even smaller than Q.

$$x_1 = \cos 26° 34' = 0.89442$$

$$x_2 = \sqrt[3]{0.89442} = 0.96350$$

Substituting this value in Equation (9) gives

$$\frac{P_1}{P_2} = 0.556$$

The smallest possible angle is of course 0 deg., for which

$$x_1 = \cos 0 = 1, \quad x_2 = 1$$

and

$$\frac{P_1}{P_2} = \frac{1}{\sqrt{3}} = 0.577$$

$\frac{P_1}{P_2}$ varies little and, if an average value is accepted,

$$\frac{P_1}{P_2} = 0.567 \qquad (11)$$

the error will not be more than 2 percent.

In order to develop the second part of Equation (8), $(x_2 - x_1)$, assume

$$x_1 = 1 - z \qquad (12)$$

Substituting Equations (12) in (7b)

$$x_2 = \sqrt[3]{1 - z} \qquad (13)$$

This expression can be developed into a series by means of the Binomial Theorem

$$x_2 = \sqrt[3]{1 - z} = 1 - \frac{z}{3} - \frac{z^2}{9} - \frac{5z^3}{81} +$$

Since x equals the cosine of "a", which, as previously explained, can only be a small angle, it will not differ much from 1; in other words, z will be

small and neglecting $z^2/9$ and all the following terms gives

$$x_1 = 1 - \frac{z}{3} \qquad (14)$$

The largest error thus made, "a" being limited as above, will be about 2 percent.

Applying Equations (12) and (14)

$$x_2 - x_1 = (1 - \frac{z}{3} - (1 - z) = \frac{2z}{3}$$

Replacing z by x_1 again

$$x_2 - x_1 = \frac{2}{3}(1 - x_1) \qquad (15)$$

Now, substituting Equations (11) and (15) in (8)

$$f' = 0.567 \times \frac{2}{3}(1 - x_1) = 0.378\ (1 - x_1)$$

Since x_1 is only an auxiliary quantity, it is replaced by "cos a", according to Equation (10), and the final equation for the "Maximum Expected Deflection" is

$$f^1 = 0.378\ (1 - \cos a) \qquad (16)$$

This equation furnishes approximate values, the largest error being about 4 percent. Considering the nature of the problem, such an error should hardly make any difference.

The results of Equation (16) are shown in the chart Fig. 4. For very small angles, however, the equation should be used. Equation or chart furnish the information necessary to decide whether a toggle joint will be stable or unstable. It will be stable if the deflection f, under the load for which the mechanism is intended, is less than f' as found for the particular angle "a".

Assume that it is required to design a frame for toggle mechanism. The force to be applied is Q, the force to be obtained is P and the length of the links is L. In this case the following steps must be taken:

1. Find the angle "a" from Equation (1).

2. Find f' for the angle "a" from Equation (16) or from the chart, Fig. 4. Since f' is for links of one inch length, it must be multiplied by L.

3. Divide the result by a suitable factor of safety S.

4. Design frame sufficiently strong so that the deflection under the given load P will be $\frac{f'L}{S}$ or less.

It should be noted that throughout this article the deflection is understood to be the deflection of the frame from the centerline to the end of one link; in other words, it is the deflection of half the frame. It should also be kept in mind that the deflection of the link itself should be included in the calculation, since a compression of the link decreases the angle in exactly the same manner as an extension of the frame.

As pointed out before and shown on Fig. 3, the actual deflection F will be more than the expected deflection f. The ratio F/f, which is also the ratio between the actual and the expected force, can be found from the chart Fig. 5. Theoretically there should be a number of curves for different angles. These curves, however, would be practically identical, especially if S equals 2 or more. Consequently the chart is only dependable for that range of S. It does allow one to find the actually obtained force; it can easily be seen that for any practical safety factor, the actual force exceeds the expected force only slightly.

An application will illustrate the use of the chart Fig. 4. Assume that a toggle mechanism as shown in Fig. 1, has been designed for a load $P = 80{,}000$ lb. The links are 12 in. long and have a section of 3 in. by 2½ in. The frame consists of two beams or heads with a 5 in. by 6 in. section and two tie rods of 2 in. diameter. Let the distance between the centers of the rods be 18 in. and the length of the rods between nuts be 42 in.

It is required to find at what angle the mechanism could be operated safely, the safety factor being 4.

The expected deflection can be found by calculation. It is composed of the deflection of the parts as follows:

compression of one link	0.0043 in.
bending of one head	0.0036 in.
extension of the tie rods (considered 21 in. long)	0.0090 in.
	0.0169 in.

This value is to be divided by 12 (the length of the links) and multiplied by the safety factor 4, the result being 0.0056 in. According to Fig. 4, this is the "Maximum Expected Deflection f'" for an angle "a" of about 10°; consequently the toggle joint should be adjusted for this angle. The force Q can now be found by means of Equation (1).

$$Q = 28{,}000 \text{ lb.}$$

If a smaller force Q should be desired, the design of the toggle mechanism must be changed. The frame and the links would have to be heavier; this in spite of the fact that the construction, as described above, is heavy enough as far as stresses are concerned.

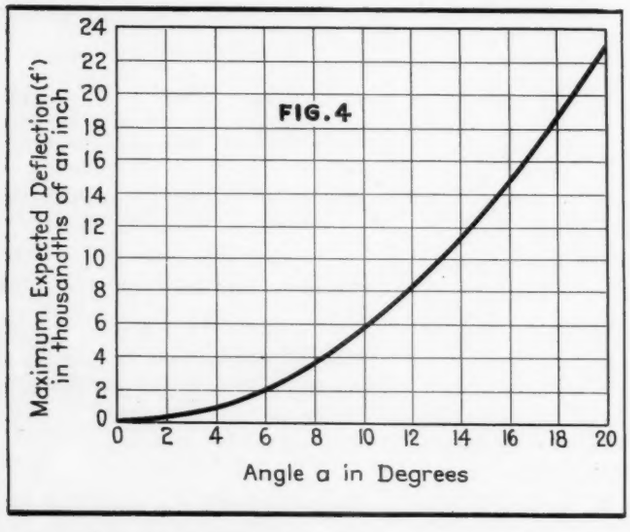


Fig. 4—Graphical presentation of Equation (16) showing, for all usable angles, what deflection touches shaded area of Fig. 3

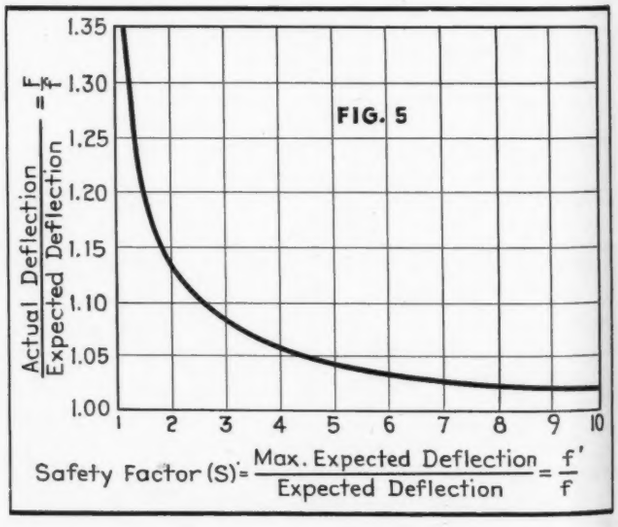
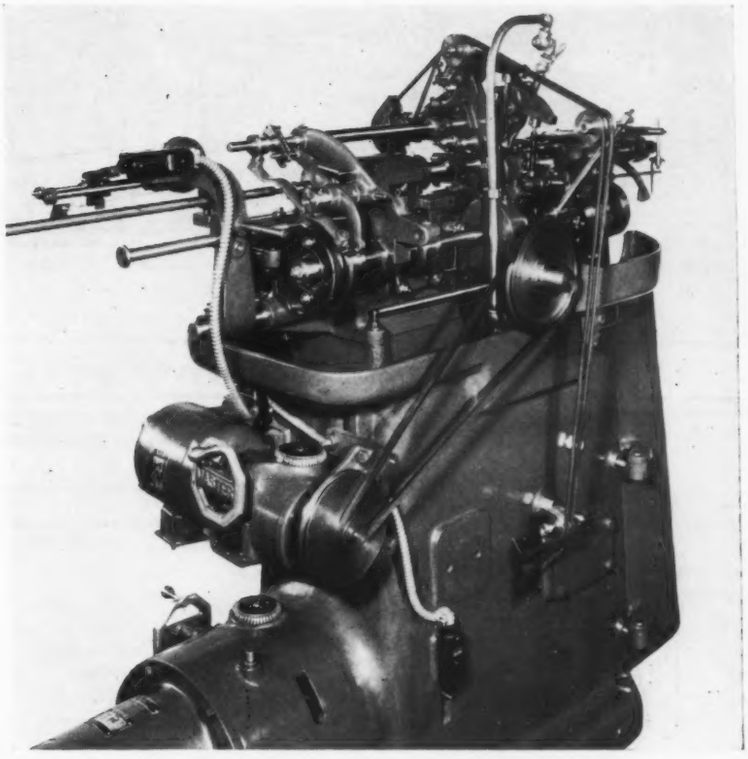


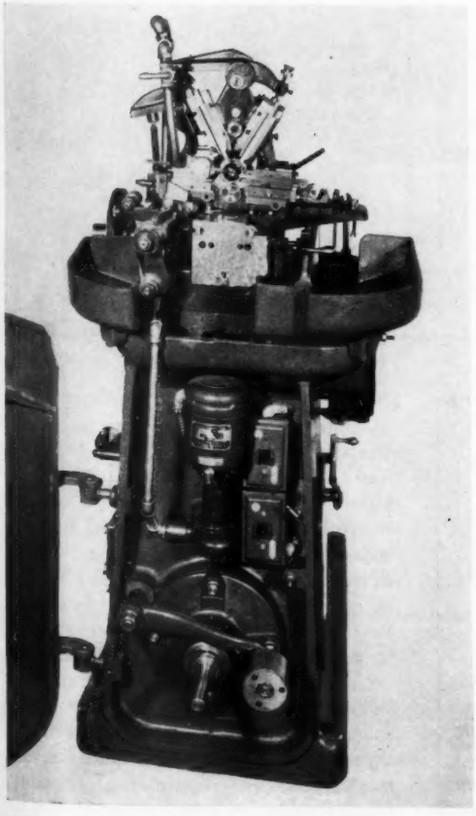
Fig. 5—The greater the safety factor the more nearly does designed frame deflection approach the actual deflection

Modern Designs

Variable-Speed Units Drive Screw Machine

Change pulleys and pickoff gears in Ceco precision automatic screw machine have been eliminated. In their place, City Engineering Company designers have put two independent variable-speed drive units—one for spindle and one for camshaft. Speed adjustments can be made by handwheels while machine is running, and give infinite speed changes and ratios. Dial tells actual spindle speeds. Mechanical principles involved in tool slides and stock guide supports are not new, but are improved adaptations of Swiss type screw machines used for many years in watch and precision instrument manufacture.





Camshaft drive unit, mounted outside on back of base, is standard Master Speed-Ranger with ¼-hp. motor. Two-step cone pulleys drive worm-gear unit on camshaft, and double the range of speeds available so that the unit can be set for camshaft speeds ranging from one revolution in 3 sec. to one revolution in 4 min. 3 sec.

Spindle drive unit is Speed-Ranger with housing specially designed to fit into base of machine. Motor is 1½-hp., 1,725 r.p.m. Infinitely variable settings of metal-to-metal friction cone drive give spindle speeds ranging from 675 to 6,100 r.p.m. Dial on drive unit is calibrated to give direct reading of spindle speed.

In this machine, four tool bits turn and face the work as the revolving bar stock is fed forward through the work guide bushing. Guide bushing, located just back of the bits, serves as a steady rest. Tools are mounted on rocker mechanisms which are pivoted off center of the stock. Rockers are actuated by flat cams on camshaft so that tool bits are advanced radially or receded from the stock. Odd shapes, radii, and tapers can be formed by generating the cams. Drilling and slotting operations are performed by attachments.

Attachments are mounted on pad at end of machine. Drive for these attachments is from pulley keyed to projecting end of main drive shaft. Coolant pump, Ruthman Gusher type, with 1/10-hp. motor, and electrical controls are mounted within base, and are easily accessible by opening welded steel door at front of base. Cover plate on side of base gives access to spindle drive belt, main drive shaft and bearings.

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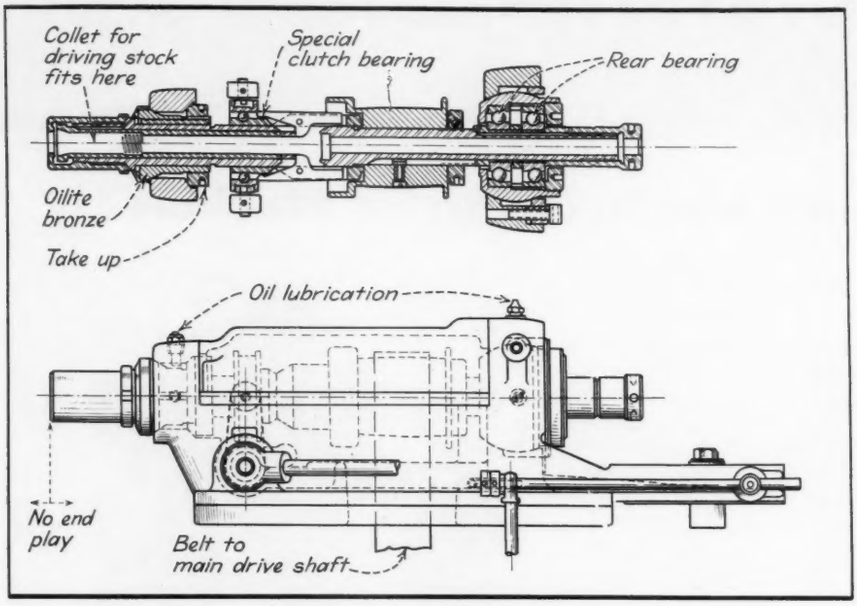
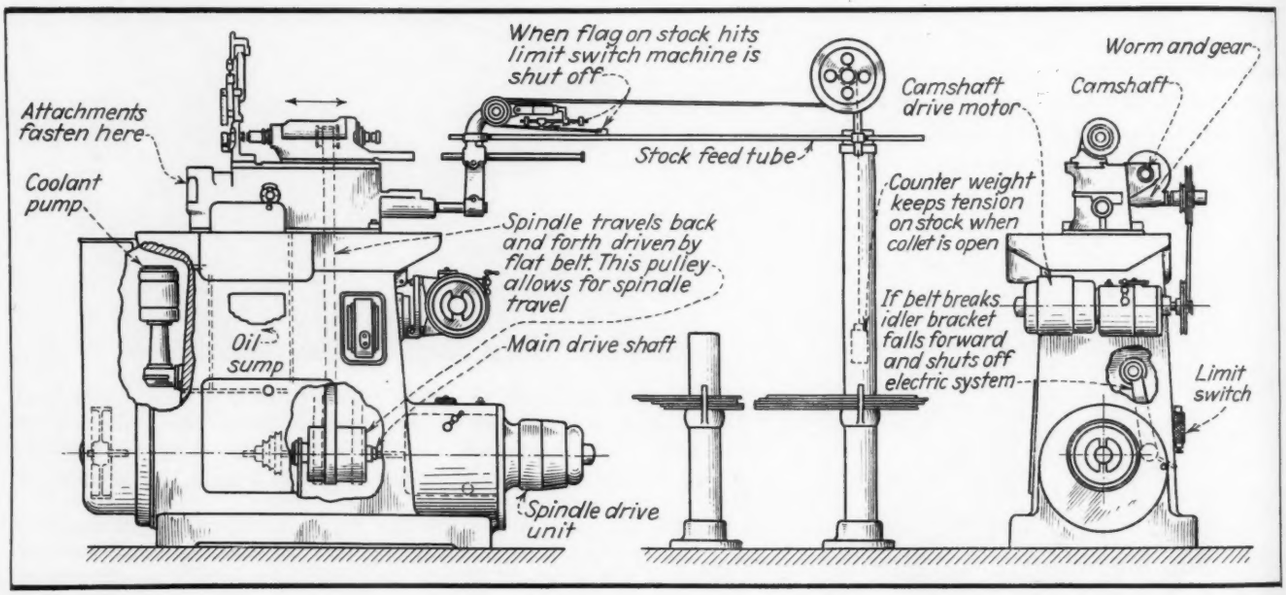
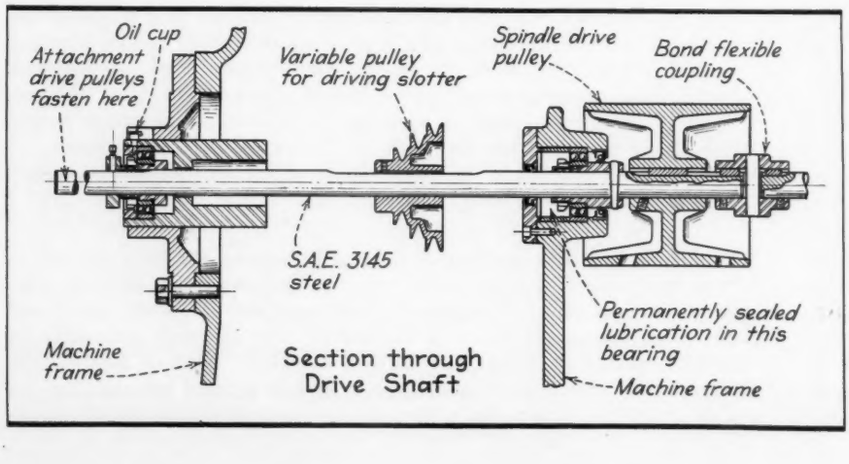
MODERN DESIGNS – Variable-Speed Units *(continued)*



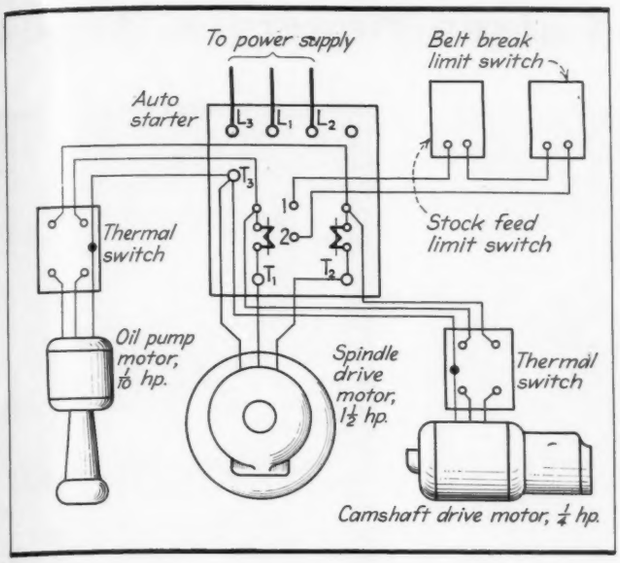
Headstock travels back and forth on ways to feed stock to cutting tools. Spindle is of alloy steel, heat-treated and ground. Front bearing is porous phosphor bronze, with screw take-up adjustment. Rear bearing is self-aligning, pre-loaded, double-row ball bearing, and also has take-up adjustment.

Stock is placed in a slit steel tube. Wire fastened to pusher in tube passes over pulley and back to counterweight-actuated reel, and maintains tension on stock when collet is open and headstock is returning for next cycle. When stock is nearly used up, flag attached to pusher contacts limit switch, shutting off motors. Safety features of machine include automatic stoppage if attachment drive belt or spindle drive belt should break.

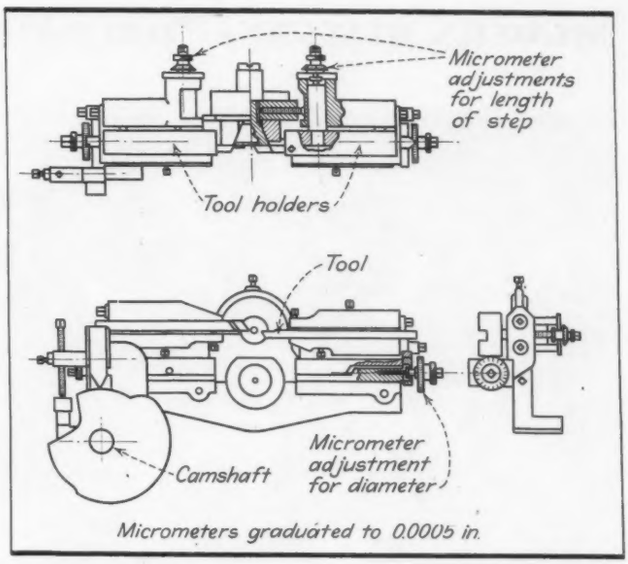

When flag on stock hits limit switch machine is shut off
Worm and gear
Camshaft drive motor
Camshaft
Attachments fasten here
Stock feed tube
Coolant pump
Counter weight keeps tension on stock when collet is open
Spindle travels back and forth driven by flat belt. This pulley allows for spindle travel
If belt breaks idler bracket falls forward and shuts off electric system
Oil sump
Main drive shaft
Limit switch
Spindle drive unit



Main drive shaft connects to variable-speed drive unit through Bond flexible coupling to eliminate vibration and give quiet operation of screw machine. Double-row, self-aligning ball bearing at motor end is sealed and permanently lubricated. Long pulley on drive shaft in base permits flat spindle drive belt to "walk" back and forth with the spindle. Keyed to center of shaft is pulley for drive belt of slotting attachment. This belt passes through port in back and over two pulleys to slotter mounted at front of machine. Bearing at attachment end of drive shaft is also double-row, self-aligning ball bearing, lubricated by oil cup.

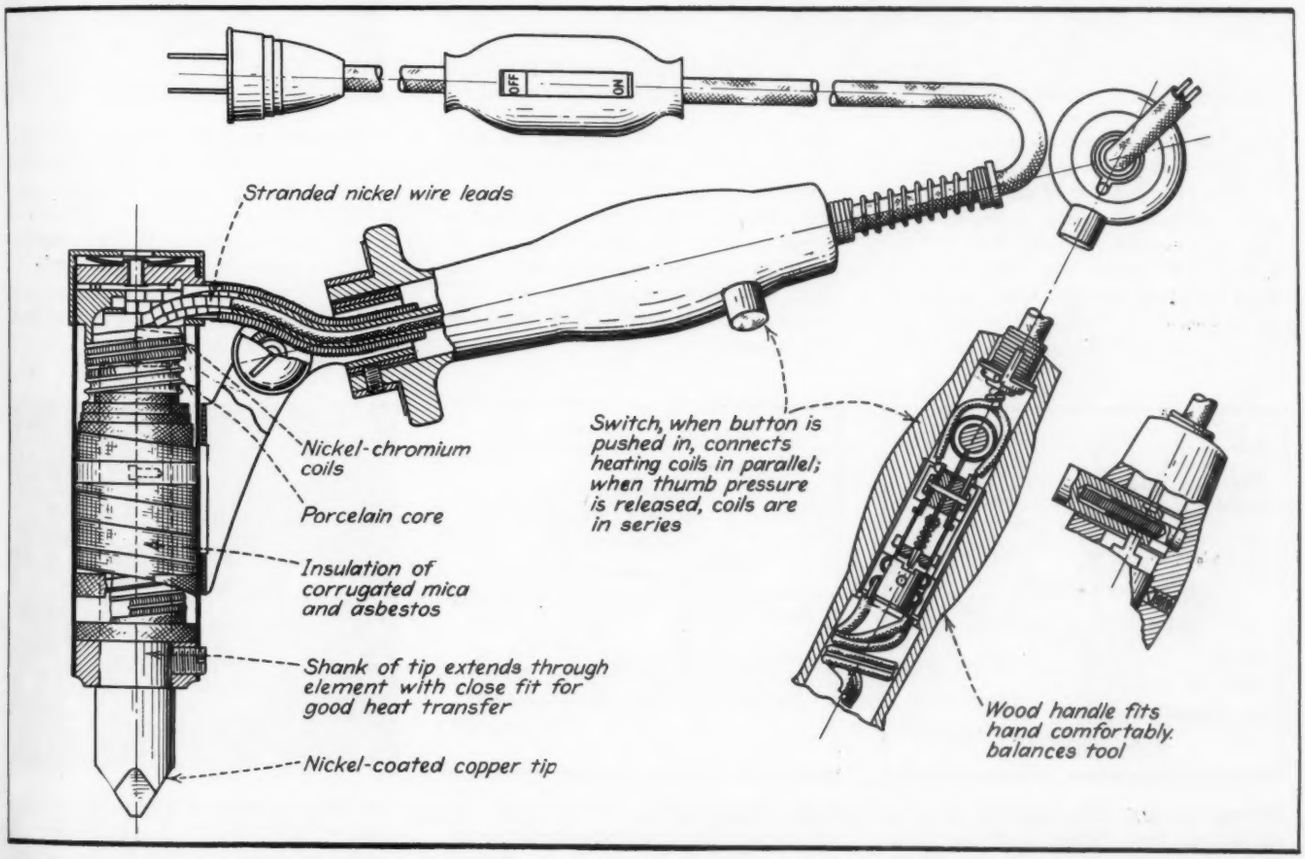


For safety, wiring circuit of Ceco screw machine is such that failure of any motor or belt stops machine.



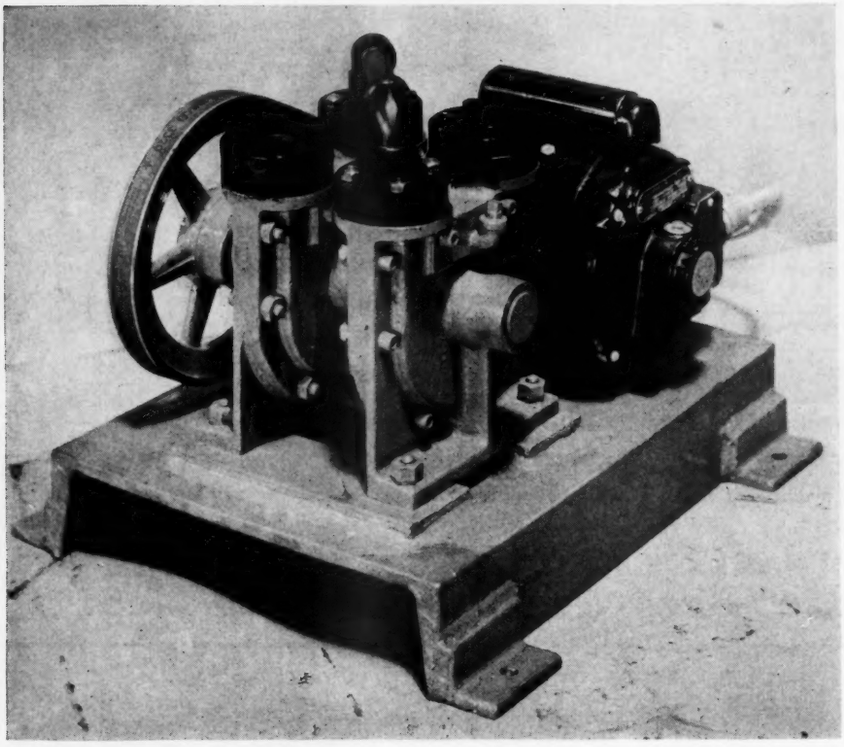
Graduated micrometer dials permit setting the cutting tools to accuracy of less than 0.0005 in. on diameter or step.

Switch in Handle Gives Quick Soldering Heat

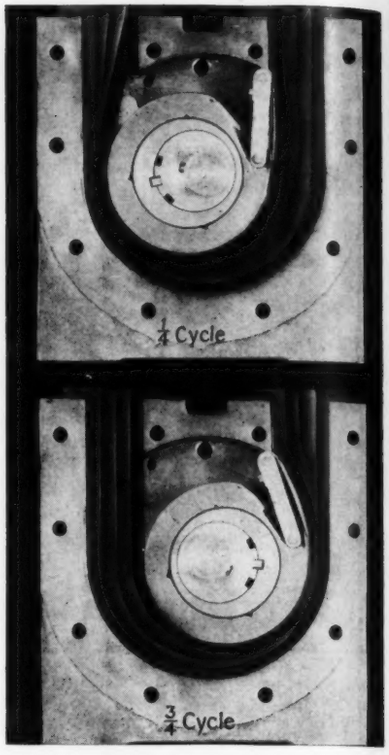

OFF
ON
Stranded nickel wire leads
Nickel-chromium coils
Porcelain core
Insulation of corrugated mica and asbestos
Shank of tip extends through element with close fit for good heat transfer
Nickel-coated copper tip
Switch, when button is pushed in, connects heating coils in parallel; when thumb pressure is released, coils are in series
Wood handle fits hand comfortably, balances tool

For fast heat when desired, heating element of McKinley soldering tool consists of two separate helical coils that are parallel-connected when button in handle is pressed, increasing wattage. With button released, coils are in series, and heat produced is not great enough to damage points if iron is left unused. Chromium-nickel coils are closely wound around porcelain core. Electrical and heat insulation is provided by corrugated mica and asbestos wrappings. Steel housing prevents admission of corrosive vapors and provides mechanical protection. Element and core is unit with terminal leads attached for easy removal. Shank of tip fits closely inside element for high efficiency which permits use of tips larger than shank. Tips are commercially pure drawn copper rod coated with nickel.

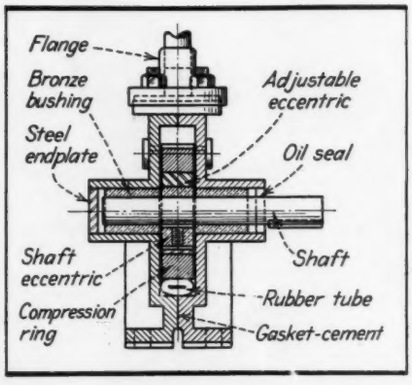
MODERN DESIGNS–Pump Has Unique "Squeegee" Action



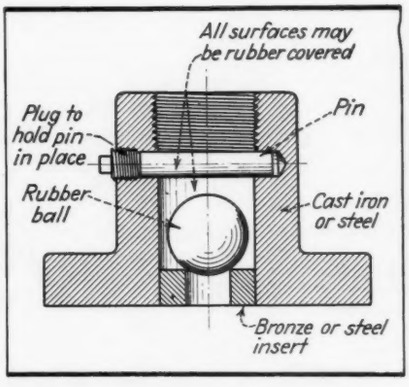
Liquids or gases do not come in contact with any metal in passing through Downington-Huber Squeegee pump. In simplest form, pump consists only of U-shaped molded rubber or synthetic rubber tube, and rotating drive shaft keyed to eccentric rotor which itself is keyed to an adjustable eccentric. Adjustment provides take-up for wear caused by internal abrasion in tube. Shaft and both rotors turn as unit inside compression ring, thus pushing ring out radially with a "rocking" action and no rubber-to-metal friction. Guard keeps tube from expanding into space over rotor. Double stage pump shown is two units connected in series with cycles 180 deg. apart.



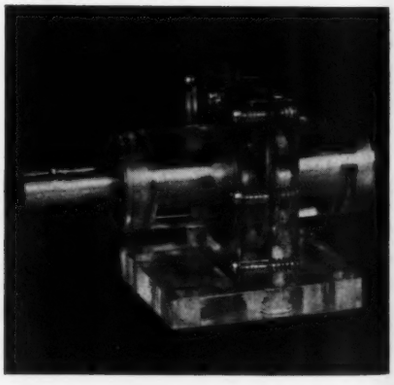
Principle of operation is unique among commercial pumps. Flexible rubber tube is squeezed between compression ring and casing; action of eccentric "squeegees" the compression point around the tube. Tube hole is molded square; compared with round hole, square section requires only half the power to collapse it.



Pump casing and compression ring are of cast iron. Shaft, of drill rod, is mounted in bronze bushings. Shaft eccentric is bronze, while adjustable eccentric is hardened steel. Plug at closed end is steel, and oil seal at shaft end is Garlock type. Inside of casing is coated with varnish for extra corrosion protection, and casing is filled with castor oil for lubrication.



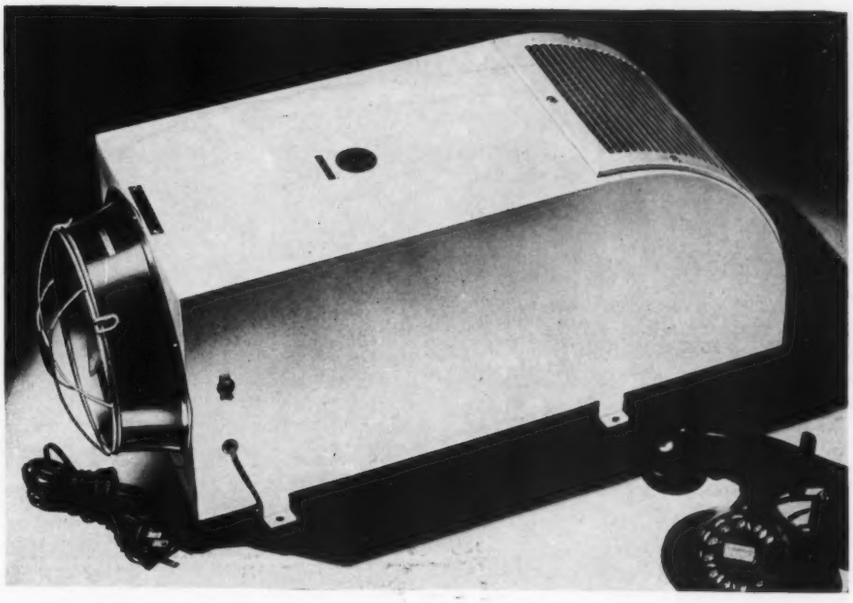
Ball check valve is necessary for single-stage Squeegee pump where pressure exceeds 20 lb. per sq. in. Simple valve sketched above fits into outlet flange, and is made of materials from which pump housing and fittings are made. Pin is of bronze, steel, or rubber-covered, depending upon service. Insert is of bronze or steel, pressed into cast iron or rubber-coated flange.

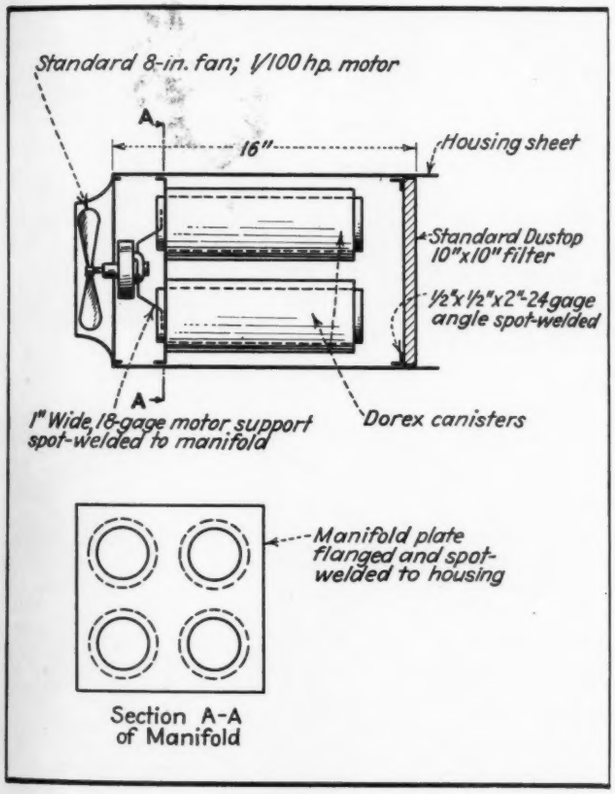


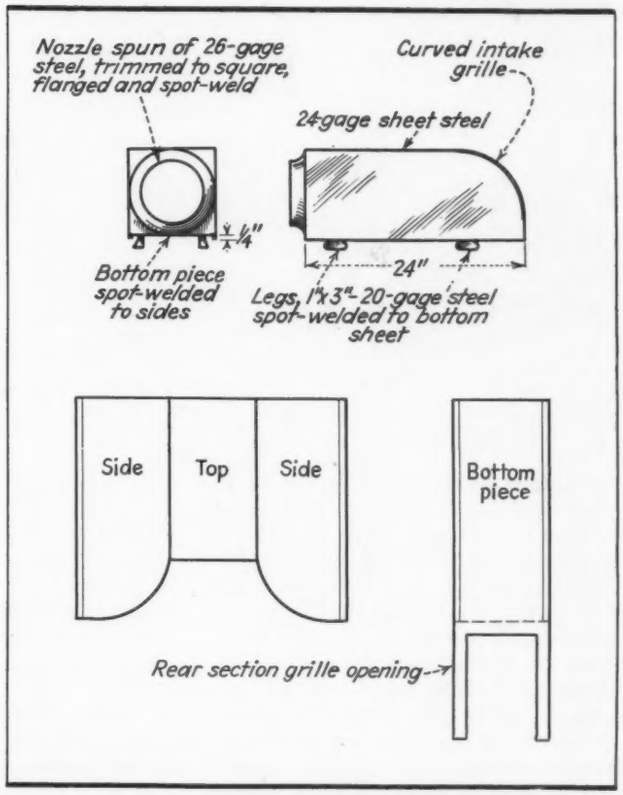
Smallest pump of Squeegee line has capacity up to 6 gal. per hr., develops discharge pressure of 25 lb. per sq. in. Original plans were to make casing for this model of acrylic resin, but shortages of plastics have caused substitution of bronze castings. Weight of bronze pump is 3 lb., that of plastic pump is 1 lb. No bronze bushings are necessary with this model.

Simplicity Keynotes Non-Defense Design

Principal problem in design of this small Dorex room odor adsorber was to make a unit that could be fabricated by semi-skilled workers without purchasing new machines and dies which are unobtainable for non-defense work. Consequently, all accessories are standard catalog items. Casing is sheet steel, spot welded, but was designed small so as not to aggravate steel shortage. Plywood or fiber board can be substituted in the casing if sheet steel becomes unavailable. Operation of the unit is as follows: Odor-laden air is drawn in through rear grille, through standard filter unit, then through four standard activated-carbon filled canisters which remove all entrained gases and odors from the air. Clean and odor-free air is then discharged back into room by fan at rate of 100 cu. ft. per min. Weight is reduced to a minimum.



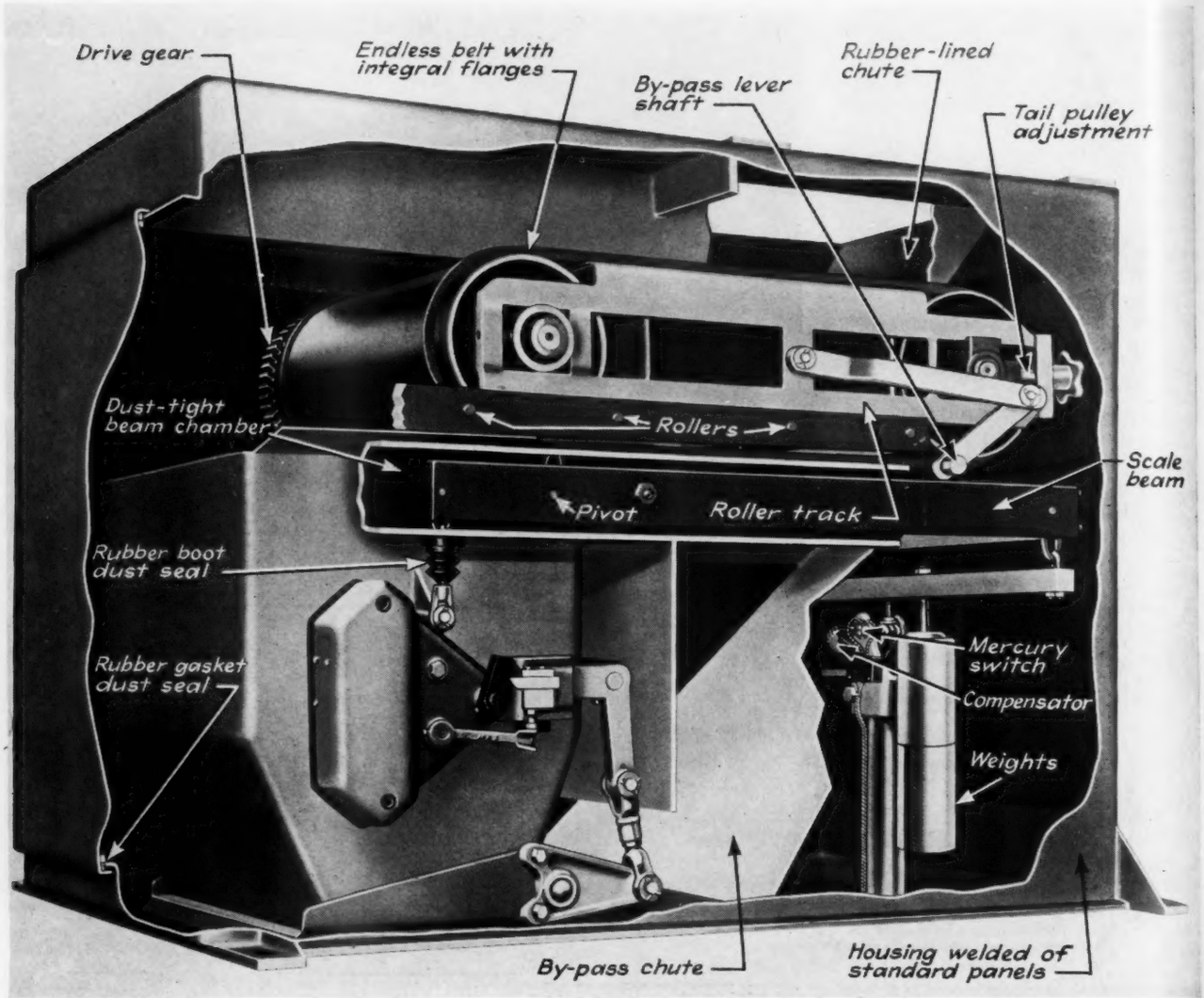




Elements of odor adsorber are all standard stock items. Filter is 10 x 10 in. Dustop unit and can be purchased in any locality. Adsorber canisters, of which there are four, are standard Dorex units approximately 11 in. long and 4 in. dia., spot-welded to sheet steel manifold plate. Fan has standard Torrington steel fan blade with 1/100 hp. motor mounted on sheet steel bracket. Nozzle is designed so fan blade will deliver required 100 cu. ft. per min. against 0.18 in. water gage resistance of filter and canister. Snap-on wire fan guard is purchased from lamp shade manufacturer.

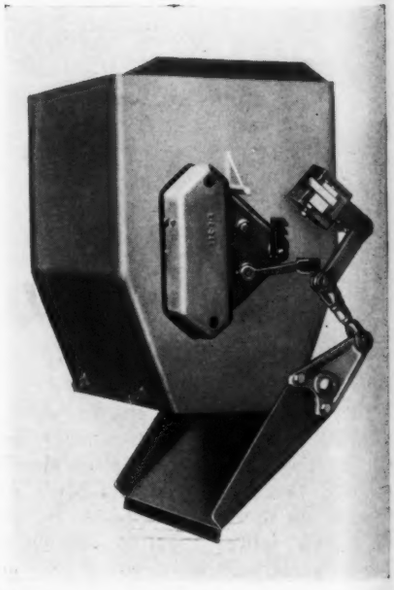
Streamlined casing is fabricated of sheet steel by spot welding. No box brake or special equipment is required. Stamped grille is standard size purchased from stock (Pliavane). It is bent to shape in a simple jig on a bending roll and is assembled to casing by self-tapping screws. Nozzle at first was spun aluminum attached to sheet steel front piece by self-tapping screws; now it is one-piece steel spinning, trimmed square, flanged and spot-welded to casing. Finish of casing is air-drying cream enamel, one primer coat. Aluminum nozzle is buffed; steel nozzle is enameled.

MODERN DESIGNS – Coal Scale Has Dust-Tight Housing



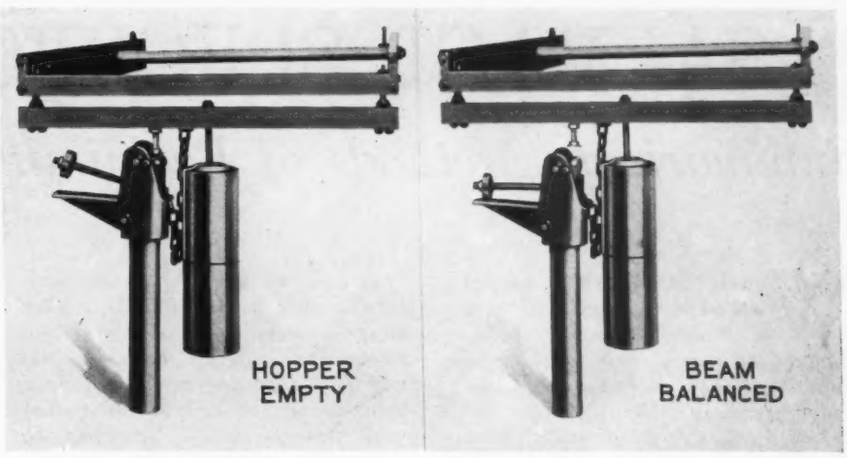
Principal design features of new Seco coal scale are its dust seals, accessibility of major units, all-welded monocoque housing, and simplicity of electrical control circuits and mechanical design. In operation, the swing bottom of the weigh hopper closes when freed by diminishing coal pile. This closes interlocking switch on side of hopper, causing (1) feeder drive motor to start, (2) electrical latch to lock hopper bottom. Conveyor then feeds coal until weigh hopper balances beam; mercury switch operated by beam then interrupts control circuit and motor is stopped by solenoid brake. Simultaneously, electrically operated latch on hopper is released and bottom falls open under weight of coal. Cycle may repeat as often as twice a minute.

Housing is of monocoque construction, welded of standard size panels. Access doors are dust-sealed with rubber gaskets. Beam and all electrical devices operate in dust-sealed chambers. Feeder unit, consisting of rubber conveyor and frame, is mounted on rollers so that it can be rolled to end of housing in case of power failure. This permits coal to feed by gravity down the bypass chute. Conveyor is sloped slightly so water will drain into hopper, minimizing corrosion of scale interior. Coal dust is the only lubricant for case-hardened drive gears.



Weigh hopper, shown with bottom open, is welded of 11-ga. stainless steel (13 percent chromium) for resistance to sulphur acids present in wet coal. No bolt or rivet heads impede coal flow. Counterweight acting through toggle mechanism closes the gate with 460-lb. force. Latch is mounted on counterweight.

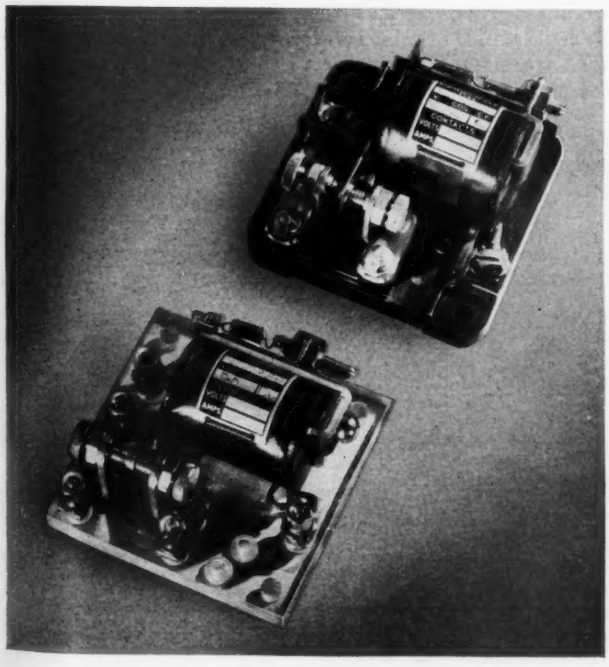
Drive of coal scale is from totally-inclosed motor through worm gear reducer with heavy-duty ball bearings, phosphor bronze wormwheel and hardened and ground steel worm. Brake housed in reducer, consists of two shoes closed by spring action and opened by solenoid wired in parallel with motor.



To allow for coal in mid-air as the motor and belt stops, this compensator has been devised to start the beam of the scale on its upward swing an instant before weight of coal in hopper brings scale to balance. The device shown above has adjustable counterweight, and produces a slight upward thrust on the end of the beam. For testing, a switch is provided to keep hopper bottom closed after beam comes to balance. If compensator is properly adjusted, the beam will balance perfectly after the last piece of coal has fallen into the hopper. Compensator shaft has sealed aircraft ball bearings.

Materials Changes in Electrical Devices

Redesigned insulator base of relays used in aerial military photography is now made of acrylic resin (Plexiglas) instead of molded phenolic resin. Reason for change, according to Kurman Electric Company, was to obtain better electrical characteristics at high frequency, and lower moisture absorption. New base is cut from flat sheet, drilled and countersunk. At frequencies above 40 or 45 megacycles the base resists carbon tracking and dielectric break down better than older types of plastics. Being thermoplastic with greater resilience and impact resistance, the acrylic base reduces danger of breakage. Low weight is another advantage; the equipment is used in aircraft.



High-frequency iron saves aluminum in radio manufacture by obviating necessity for aluminum shields and aluminum variable condensers. Closed-core coil shown has Crolite high-frequency powdered iron core and shield, forming complete electromagnetic shield. Powdered metal acts same as laminated core in preventing induced currents in core. For open-core coil used for permeability tuning in place of aluminum plate condenser tuning, powdered iron sleeve around winding serves as electromagnetic and electrostatic shield. In some cases auxiliary shields of copper foil over paper tubes are placed around sleeves. Permeability tuning is done by mechanically moving high-frequency iron cores in and out of a gang of coils to alter inductance. Transformers made with high-frequency iron are compact and show some performance gains. Uses are increasing in military equipment and auto and portable radio sets.

SALVAGE SPECIFICATIONS

Summarizing Methods of Reclaiming Defective Parts

WITH PRODUCTION stepped up terrifically, and with men of limited experience operating production machinery, working in foundries, forges, and other shops, the scrap percentage has generally increased. In view of the present defense manufacturing situation, every piece counts. If it is possible to salvage a defective part so that it can perform with full satisfaction for the service intended, the part should be saved to conserve both material and man hours.

There should be no stigma attached to a salvaged part, for in many instances it is just as good as if it had been made perfectly in the first place. Indeed, sometimes a salvaged part is superior to a part manufactured strictly according to specifications. The question of salvage must be answered in light of the service to which a part will be subjected when in use. Thus, the situation has thrown an added burden on the engineering design department because any specifications relating to the salvage of defective parts must be passed upon, if not originated, in the engineering department.

Solution to all reclamation problems can only be accomplished properly by the combined efforts of and consultation between the inspection, production, and the engineering departments. The production department may suggest means of salvage or manufacturing changes to prevent defects, but it is the engineer who makes the final decision as to what tolerances a part may be held and still provide the service required. He, in turn, submits his recommendations to the chief inspector who decides whether the part is acceptable for a given application. For example, a production man may suggest brazing as a method for salvaging a pump housing. The engineering department, knowing the service in which the pump is to be used, must determine whether the liquid handled is going to affect or be affected by the brazing. Among companies operating a salvage system on such a basis is Caterpillar Tractor Company, of Peoria, Ill.

Among methods of salvaging are welding, both gas and arc, coating surfaces with liquid resins, plugging (for small holes), brazing, spraying metal, hard surfacing, and plating.

Castings, of designs of all sorts, probably offer the most fruitful field for salvage by welding. Holes in gray iron castings can be filled by gas welding. Such holes must first be chipped clean so that the wall of the hole will be solid metal at every point. The castings are then preheated to 900 deg. F., gas welded with a low carbon rod, and the casting annealed at about 1200 deg. F. to relieve stresses and eliminate hard spots.

Porosity and blow holes in steel castings may be cleaned out and arc welded in a similar manner. The casting may or may not be stress relieved, depending upon the service required and the nature of the repair. If the welded section will be subjected to stress, the casting should be annealed.

"Repairs" Are Often Improvements

The repair of castings by welding should not be looked upon as subquality workmanship. In fact, many designs call for a combination of castings and welded-on parts. Diesel engine frames, marine engine frames and similar structures that are subjected to tremendous loads are now, in many cases, designed as a combination of cast and welded parts.

A casting that has cracked from shrinkage stresses and has been salvaged by welding is far superior to what it would have been had the strained casting not cracked. The presence of the crack is prima facie evidence that the casting had high shrinkage stresses in it, and finally cracked to relieve these stresses. When such a casting is then salvaged by welding and annealing, the casting is free of internal stresses and is, therefore, stronger than it would be had it not cracked.

Under the subject of welding is "hard-surfacing," or facing, in which a surface may have welded on it a coating or edge of abrasion resisting material. The area to be faced should be free of foreign substances such as rust and scale. Practically any standard fusing method may be used. Many applications for facing have been found in the automotive industry for such parts as engine valve faces and seats, pump shafts, universal joint bearings, and clutch plate pressure areas.

Design engineers are becoming increasingly aware that they must eliminate in the casting design all points at which porosity, shrinkage stresses, sand washes and similar casting defects might occur. An example of this can be found in the design of a high-pressure fitting which has extremely thick flanges. It was found impossible, by any foundry technique employed, to pour the casting so that there would not be any blow holes and shrink holes in and near the heavy flanges. The problem was finally solved in the design of the casting, as shown in Fig. 1, by

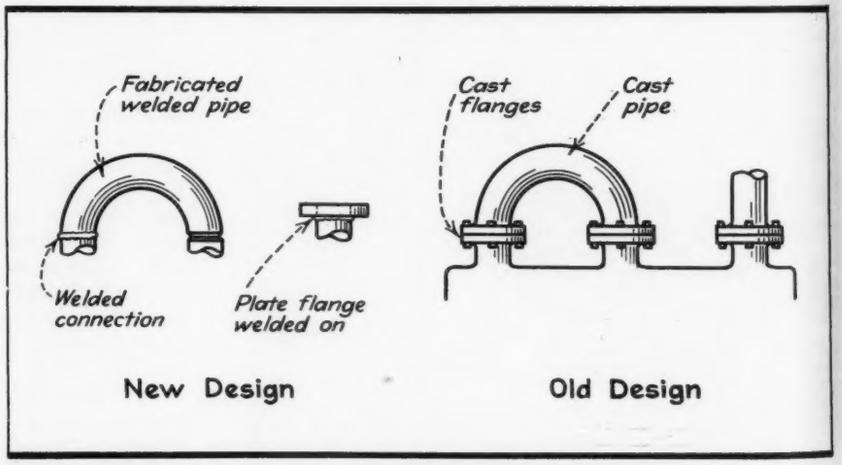


Fig. 1—In the old design, porosity occurred around cast flanges. Connecting pipe and flanges of welded construction eliminated this defect

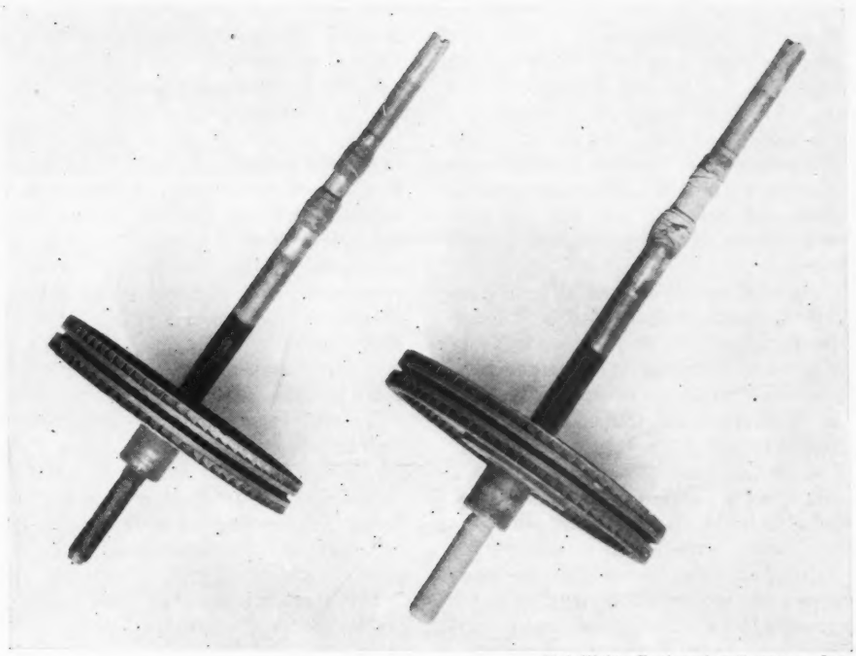
eliminating the flanges which were then made separately out of heavy steel plate and welded to the casting.

Porosity in pressure castings such as cast elbows, cylinders for freon compressors, chemical pumps, and similar parts may be filled with phenolic resin. In this process, all openings in the castings are closed, a liquid phenolic resin poured in, air pressure applied, and the casting rotated so that all of the interior surface gets a thick coating of the resin which is forced into all pores by the air pressure. When pressure is released, stoppers are taken off the openings, surplus resin varnish is poured out, and the casting is then baked at a temperature of 250 deg. F. This permanent repair improves the casting by giving it a smooth internal coating resistant to most corrosive liquids.

When a casting has only a few small holes, it may be satisfactorily repaired by drilling out the holes, reaming them to a taper, and then driving in soft steel plugs. The small diameter of the tapered plug should always be at the surface where damage would be done if the plug worked out. Thus, in engine cylinder castings, the larger diameter of the plug is always on the outside surface.

Brazing is an excellent method for salvaging cracked castings, provided the casting will not be subjected to high service stresses in the vicinity of or through the cracked section. In brazing, the casting need be preheated only moderately or not at all. Usually the casting is preheated to 300 or 400 deg. F., primarily to take out the chill. Since the resulting brazing repair is highly ductile, stress relief is not necessary.

In the foundry, experienced foundry men will resort to burning a casting that has been poured short. After the casting has been taken out of the sand, and the shortness discovered, the casting is preheated and a sand mold is built up around the incomplete section. Hot metal is then poured into this open mold cavity until the metal has been heated to the fusion point. The result is that the poured metal and the original casting are fused together without any line of demarcation.



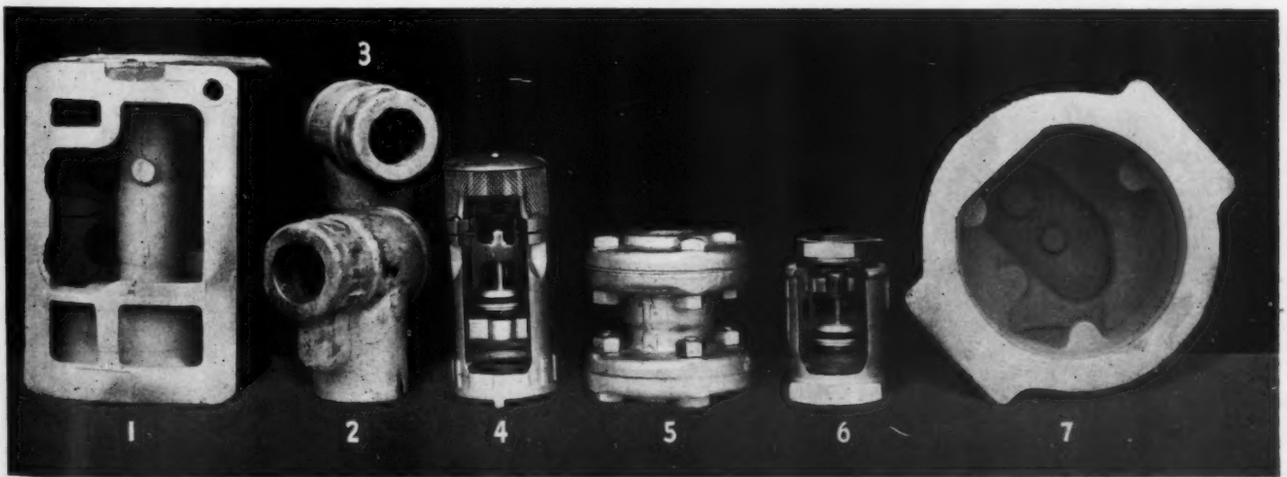
Metallizing Engineering Company, Inc.

Fig. 2—Locomotive headlight turbine shafts. Shaft left roughened at worn areas preparatory to spraying. Shaft right sprayed with steel but not yet finished ground

Metal Spraying

Metal spraying has been used for many years for building up worn machine elements such as shafts, spindles, pump rods and plungers. Today, this process takes on a special significance since industry is finding that many of its well-established maintenance operations can be employed with equal effectiveness, and with comparable savings of time and material, on the production line. For instance, parts that have been machined undersize are being salvaged just as efficiently and as easily with metallizing as those that are worn. Still more important in these times is that these parts are passing rigid government inspection.

Metallizing employs any metal which is obtainable in wire form. Since no appreciable amount of heat is transmitted to the base metal during the



Metallizing Engineering Company, Inc.

Fig. 3—Typical parts after metallizing with zinc. (1) Rotary pump body. (2) and (3) Angle check valve. (4) Foot valve. (5) and (6) Line valves. (7) Meter cover

spraying process, there is no danger of warping, crystallization, and heat strain. Furthermore, metal spray coatings may be applied in any desired thickness to parts and equipment of any size and dimensions, regardless of the characteristics of the base material. It is necessary only that the base metal be clean and dry, and prepared by sand or grit blasting, or by roughening with a tool.

Sprayed metal is especially well accepted for the maintenance of automotive parts and can be just as effectively adapted to their production. In the June 1941 issue of *Bus Transportation*, Mr. A. F. McDougald, Superintendent of Automotive Maintenance of the Capital Transit Company, Washington, D. C., tells how his garages are using sprayed metal to build up worn crankpin bearings, water pump shafts, brake cam shafts, and valve stems. Besides mentioning the economy and speed of metal spraying, he states that not one failure has been reported. He quotes one instance where a sprayed crankshaft has given more than 100,000 miles of satisfactory service.

Internal and External Fits

The restoration of press fits of all sizes is another important job being done successfully by metal spraying. For instance, worn or damaged bearing housings in iron, magnesium, or aluminum castings are quickly restored to size by building up with sprayed metal and re-boring. On external press fits, the diameters of axles and spindles are first metal sprayed oversize and then machined to final dimensions. These are typical applications that may be used not only to overcome wear but to rectify mis-fabrications.

Westinghouse employs metal spraying in the production of shafts for Type C single-stage turbines. Although this application is not used to reclaim mismachined parts, it goes a long way in eliminating scrap because it greatly retards wear at the two gland zones, which are sprayed with high chrome-nickel steel.

A large majority of the magnesium and aluminum castings that are rejected ordinarily because of superficial surface defects, now can be reclaimed with minimum effort, and at little cost, by a technique recently developed by Metallizing Engineering Company, Inc., in collaboration with Dow Chemical Company.

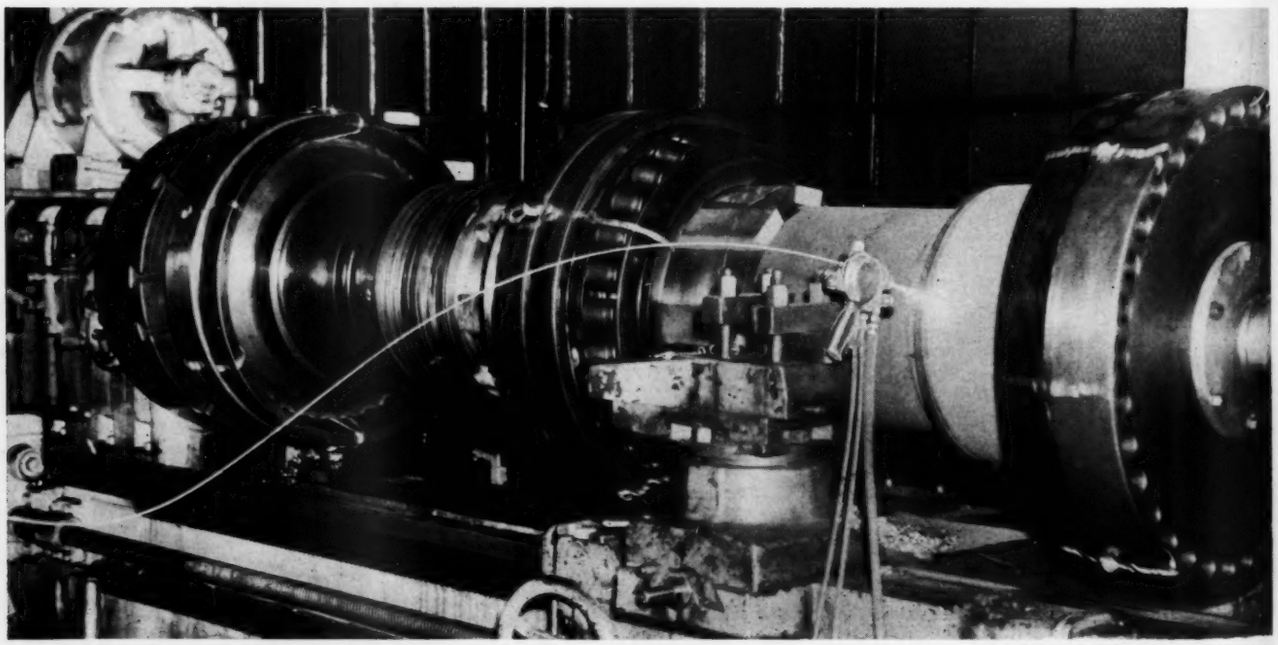
This technique should relieve considerably the production bottlenecks and expense caused, for instance, by spongy areas and blow holes. Often such defects are not noticeable on the surface but appear only in the last stages of machining and finishing. Furthermore, this method of reclamation should eliminate a considerable number of rejects caused by mismachining.

Chromium Plating in Salvage

Chromium plating has been used effectively for many years to build up worn crankpins. This is another instance wherein the repaired parts are superior to the original parts. In a number of plants, bearings which are undersize are often chrome plated, if they are going to be used as pilot diameters or press fits. In such cases, they are ground down 1½ thousands, plated, and then ground to size. No running bearing is ever so plated.

Occasions will still arise when it is impossible to do anything with a damaged or defective part. In such cases, scrap should be stored according to its composition so that bins of similar alloys may be kept separated and sold or remelted as a group. As aluminum or magnesium castings can be melted and recast in a comparatively short time, companies having their own casting facilities for these metals usually find it more advantageous to remelt a defective casting rather than to salvage it.

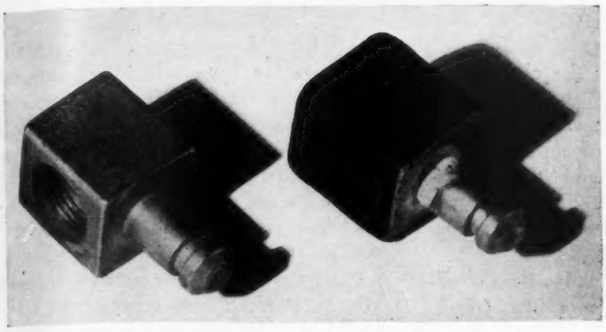
The present need for conservation may be a blessing in disguise, for customers now must learn that because a part has been subject to operations which might be classed as salvage does not necessarily mean that the finished product is inferior. Good, serviceable parts passed by the engineering department as satisfactory for their designed purpose may still be rejected by the chief inspector because his customer, the government or private concern, will refuse them. But in many instances, the so-called defective part is refused for purely traditional or prejudicial reasons rather than on the basis of satisfactory performance. For such cases, in the interest of conservation, it may be well to save these parts for possible future use when the customer's needs may dictate a practical acceptance.



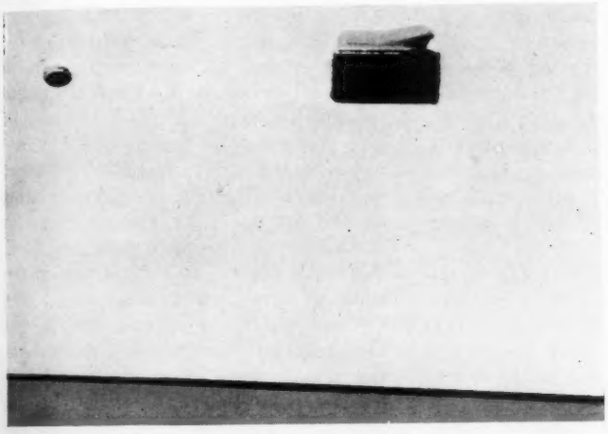
Metallizing Engineering Company, Inc.

Fig. 4—Spindle 22 in. dia. for axle testing machine is built-up at worn bearing seats with carbon steel

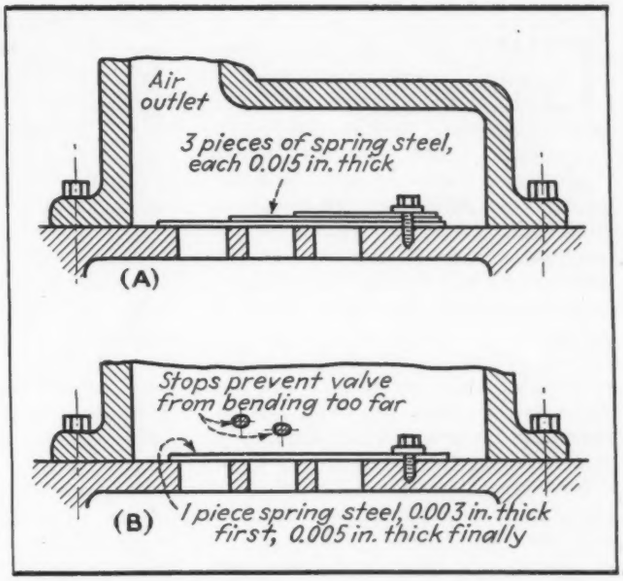
Causes and Cures



Part of carburetor mechanism had a control rod passing through its hole. Since the rod must be a loose fit, it rattled when the automobile engine was running. Designers decided to stop the rattling by lining the hole with rubber. Cheapest way was to dip entire part in latex.



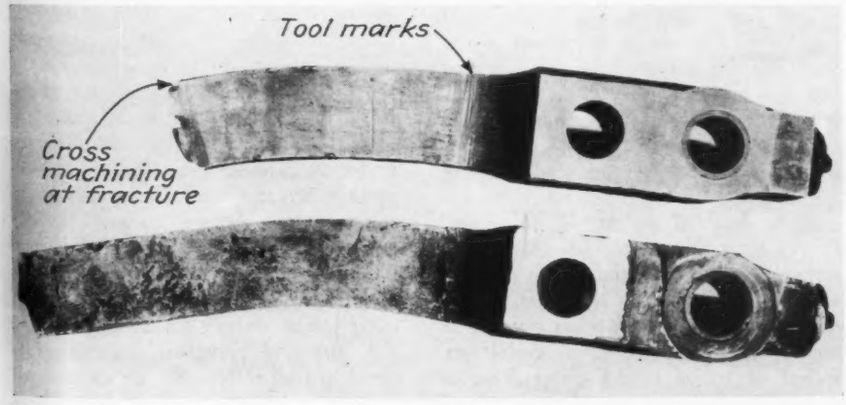
Chipping occurred around holes in this porcelain enameled piece because edges were not brushed. A rim at least ⅛ in. wide around holes should be edge-brushed down to ground coat. If accessories are fitted over holes, brush at least $\frac{1}{16}$ in. beyond accessory. By careful designing, brushed holes sometimes can be located out of sight.


Air outlet
3 pieces of spring steel, each 0.015 in. thick
(A)
Stops prevent valve from bending too far
(B)
1 piece spring steel, 0.003 in. thick first, 0.005 in. thick finally

Reciprocating pump, 4-cylinder, would not deliver sufficient amount of air. Its valves was made of three pieces of 0.015 in. thick spring steel, designed as shown in (A) at left. Reasoning that the spring was too thick, the engineer replaced it with a flat spring only 0.003 in. thick, as shown in (B), mounted with screws and a flat strip.

Immediately the pump output quadrupled. The new valve, however, was so thin that it flexed too far and shortly broke. This was corrected by placing a stop barrier above the spring steel preventing it from opening more than ⅛ in. Trouble arose again when the spring valve, in high-speed tests, began to crack and little pieces broke off. This was cured by increasing the valve thickness to 0.005 in.

After extensive laboratory tests, the pump was finally placed on the market. A year later, pumps in service began to fail. Burrs on the edges of valves were the cause. Inspection showed all valves in stock had "whiskers" sometimes ⅛ in. long. After rigidly specifying that all valve edges be ground smooth, no more trouble was encountered.



Cross machining done by the machinist who shaped these combination levers caused their failures. Fatigue cracks started in rough tool marks, some of which are plainly visible in the top lever. Cross machining is dangerous even if the tool marks seem to have been removed; lines of strained metal still remain. There is only one cure—specify a smooth finish free from tool marks and other surface defects.

PRODUCT ENGINEERING will pay a minimum of $3 for each example published in Causes and Cures. Where illustrations are necessary, include drawings, rough sketches or photographs.

PATENT PROCEDURE – II

Rights and Limitations of the Patent Grant

MILES HENNINGER
Patent Department, Allis-Chalmers Manufacturing Company

EVERY ONE talks about "patents," but few people know that the United States has three kinds of patents, namely, patents for inventions, or utility patents, design patents, and plant (the botanical kind) patents. At present we are concerned only with patents for inventions which are authorized by Revised Statutes Sec. 4886 and Rule 24 (of the Rules of Practice), the pertinent portion of the statute being:

"Any person who has invented or discovered any new and useful *art, machine, manufacture,* or *composition of matter,* or any new and useful improvements thereof, * * *"

Notice that the statute gives only four classifications for patents for invention and the Patent Office cannot grant patents on anything beyond that classification, regardless of how startlingly new or immediately useful such discovery may be.

The "art" might be better stated as "the art of doing an act or securing a result" from which it is at once evident that "art" must mean method or process, which is exactly correct. There may be both mechanical or electrical and chemical methods or processes and any of such methods or processes is patentable provided the various steps involved represent more than only the functions of the mechanisms by which the steps are carried out. The claims in a method patent always state a series of steps which must be performed to secure the result. The steps may involve employment of natural forces (Ref. 1) such as heat, light, electricity or chemical action, or mechanical steps (Ref. 2) which may be performed by hand or by the use of various mechanisms. A particularly good definition is given by the U. S. Supreme Court in Cochrane v. Deener (Ref. 3).

A "machine" includes everything from hand tools to the most complex assemblage of interacting electrical or mechanical elements. However, it is necessary that the several parts cooperate, either simultaneously or successively, in producing the desired result. The Manual of Classification will show that "machine" embraces every known means for securing a result. Note, however, that patents are not granted on even hand tool parts which fail to cooperate as in the classic case of Reckendorfer v. Faber (Ref. 4) where the combination of an eraser on the end of a pencil was held not to be a patentable combination, the pencil being no more than a handle for the eraser which performed its own separate function.

A "manufacture" includes such structures as building, highway structures, clothing, fences and the like (Ref. 5). The line between machine and manufacture is not distinct, but it is not important. So long as the invention falls in either class, a patent granted thereon is entirely valid.

"Composition of matter" includes all articles made of two or more substances, whether chemical combinations or mechanical mixtures, or having some of the qualities of both such combinations and mixtures. The Manual of Classification contains classes relating to various kinds of chemical compounds, compositions, alloys and mixtures, such as paints, explosives, artificial ivory or glass.

The grant of a patent (see Fig. 6) is similar to the grant in a deed and defines exactly the area or scope of the rights which are given to the patentee. R.S. 4884 defines the grant as: "* * * a grant to the patentee, his heirs or assigns, for the term of seventeen years, of the exclusive right to make, use, and vend the invention or discovery * * * throughout the United States and the Territories thereof, * * *"

Notice that the grant is to the inventor and his heirs or assigns, thus providing for the issue of patents on inventions made by a now deceased or insane inventor and for the issue of patents to any one to whom an invention may be assigned by the inventor before a patent application is filed, during pendency of the application, or after the patent is issued. The life of a patent is seventeen years and there is no way in which the term can be extended, short of an Act of Congress. In the past there have been some instances of such extension and a general act (the Nolan Act) was passed following World War I to permit ex-service men to extend the terms of their then issued or to be issued patents for a short time. However, the Nolan Act is no longer in force and all patents extended thereunder have now expired. After the seventeen-year term, the patent expires and the patented invention is open to all of the public.

The statute and the grant gives "the exclusive right to make, use and vend the invention" which is not what is actually given. If the statute is read "the right to exclude others from making, using and vending," a better understanding of the true situation is obtained. In Crown Die & Tool Co. v. Nye Tool & Machine Works (Ref. 6) (see also cases therein cited) Chief Justice Taft of the U. S. Supreme Court said: "the benefit which the Government intended to secure was not the making or use of the patent for the benefit of the public during the seventeen years of the grant except as the patentee might voluntarily confer it from motives of gain but only the benefit of its public use after the grant expired. The Court held that the Government did not confer on the Patentee the right himself to make, use or vend his own invention, that such right was a right under the common law now arising under the Federal patent laws and not within the grant of power to Congress to enact such laws. * * * The Court further held that in its essence all that the Government conferred by the patent was the right to exclude others from making, using or vending his invention."

The patentee of a pioneer invention, the first means for accomplishing a given result, truly has the exclusive rights stated in the grant, but the later patentee of a secondary or improvement invention has only the right to exclude others from the invention he has made and is subservient to or dominated by the earlier pioneer invention during the life of the patent thereon. A secondary invention must therefore be licensed under the pioneer patent before the secondary invention may be used. As an example, the Edison carbon filament patent (Ref. 7) dominated all carbon filament incandescent lamp inventions and all making, using and vending of such lamps during its lifetime. Then the Just and Hanaman tungsten filament patent (Ref. 8) dominated all

2251152

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas SÖREN H. MORTENSEN, of Wauwatosa, Wisconsin, assignor to ALLIS-CHALMERS MANUFACTURING COMPANY, of Milwaukee, Wisconsin, a corporation of Delaware,

PRESENTED TO THE **Commissioner of Patents** A PETITION PRAYING FOR THE GRANT OF LETTERS PATENT FOR AN ALLEGED NEW AND USEFUL IMPROVEMENT IN

WINDINGS FOR ELECTRICAL APPARATUS,

A DESCRIPTION OF WHICH INVENTION IS CONTAINED IN THE SPECIFICATION OF WHICH A COPY IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND COMPLIED WITH THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED, AND

Whereas UPON DUE EXAMINATION MADE THE SAID CLAIMANT is ADJUDGED TO BE JUSTLY ENTITLED TO A PATENT UNDER THE LAW.

NOW THEREFORE THESE **Letters Patent** ARE TO GRANT UNTO THE SAID

Allis-Chalmers Manufacturing Company, its successors OR ASSIGNS

FOR THE TERM OF SEVENTEEN YEARS FROM THE DATE OF THIS GRANT

THE EXCLUSIVE RIGHT TO MAKE, USE AND VEND THE SAID INVENTION THROUGHOUT THE UNITED STATES AND THE TERRITORIES THEREOF.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this twenty-ninth *day of* July, *in the year of our Lord one thousand nine hundred and* forty-one, *and of the Independence of the United States of America the one hundred and* sixty-sixth.

Attest:

Law Examiner.

Commissioner of Patents.

Fig. 6—Patent not only grants a privilege but specifies its limitations

tungsten lamps made during its lifetime. Every class of inventions or the so-called "arts" have had or are still having their pioneer or basic and their improvement or secondary inventions. The making of such basic inventions continues until an art is thoroughly developed and has therefore become relatively static.

Notice that the grant gives three rights, (a) to make, (b) use, and (c) vend or sell. The unauthorized appropriation of any one of the three rights is an infringement of the patent and is basis for a suit for recovery of damages. However, the maker or vender of an infringing device is nearly always sued because the damages recoverable from a user are generally negligible. Notice also that the grant runs through the geographical territory of the United States and its territories and possessions. A U. S. patent is therefore enforceable also in Alaska, Hawaii, the Canal Zone and upon compliance with the special provisions, in the other U. S. possessions and the Philippine Islands.

The right to exclude others is, broadly speaking, a monopoly (Greek *monos poleir*, or Latin *monopolium*, meaning "alone to sell"). Early monopolies are exemplified by the grant by Queen Elizabeth of England (1559) for the sale of salt (NaCl). "The said grant was given unto him by Her Majesty in some reward for his service and is a principal part of his maintenance," as a result of which the price rose from 16 pence to 14 shillings per bushel. Or by the grant also by Queen Elizabeth to Edward Darcy of the sole right to make and sell the ordinary playing cards because "Diverse subjects of able bodies which might go to plow, did employ themselves in the art of making cards." However, side by side with the above maleficent monopolies, during the same time (1559) Queen Elizabeth granted a patent to Giacope Acontio on a new furnace, saying, "nothing is more honest than that those who by searching have found out things useful to the public, should have some fruits of their rights and labors, as meanwhile they abandon other modes of gain, are at much expense in experiments, and often sustain much loss."

By the year 1600, the view had developed that monopolies should be granted only for actual inventions made or for inventions introduced from abroad into the country, and that such monopolies were to be limited in life and were in consideration for the good done to the public. The Edward Darcy of the playing card monopoly sued (Ref. 9) one Allein for infringement of the monopoly and was defeated by the argument that: "when any man by his own charge and industry, or his own wit and invention doth bring any new trade into the realm, or any engine tending to the furtherance of a trade that never was used before;—in such cases the king may grant him a monopoly patent for some reasonable time, until the subjects may learn the same, in *consideration of the good* that he doth bring by his invention *to the commonwealth*, otherwise not."

It is interesting to note that Darcy v. Allein resulted in the Statute of Monopolies (Ref. 10) which forever barred British sovereigns from granting patents for anything other than inventions.

As early as 1800 Lord Eldon of the English Kings Bench Courts had called a patent for invention a contract between the inventor and the public in which the inventor gave a full disclosure of his invention in return for a limited monopoly from the public. The understanding that a patent is a contract and not a mere monopoly is well stated in Century Electric Co. v. Westinghouse Electric & Mfg. Co. (Ref. 11) where the Court of Appeals, 8th Circuit, said: "A patent is a contract made by acceptance by the government of the offer which the patentee by his application makes to disclose his invention, in consideration that the United States will secure to him the exclusive use and sale of it for 17 years. The offer embodied in the application becomes the

specification of his patent, if his offer is accepted, and his claims evidence the terms of the agreement. Such agreement is interpreted by the same rules that determine the construction of other contracts."

The inventor takes nothing from the public, he offers to give something which the public did not have. The patent application is his offer, the prosecution of the patent to agreement, as to allowable claims, between the inventor and the examiner is the negotiation leading to acceptance (allowance of the application) of the offer by the government. The consideration from the inventor is the disclosure of his invention and the consideration from the public is the assistance of the government in excluding others from the sale and use of the invention for 17 years. Certainly all the other essentials of a contract are also present, the parties are both competent, the object is legal and, before allowance, the examiner sees to it that the patent is in proper form.

A word as to correct terminology is required here. "Patent" can be used to mean (a) the entire document itself, the Letters Patent, issued to the patentee and including the grant, the drawing and specification and the claims (b) the grant only, and (c) the copies of drawings, specifications and claims sold by the Patent Office. In these articles the word "patent" is taken to mean the entire document. "Making an invention" may be used to designate (a) the mental act of conceiving the inventive idea and the physical act of reducing the invention to practice, or (b) the manufacturing of specimens of the invention for sale or use. In these articles "making an invention" refers to the acts required under (a). For further discussion of the nature of a patent, the reader is referred to Walker—On Patents, 6th edition, Section 200, 201, 202 and 203.

References

(1) Submarine Signal Corp. v. General Radio Co. 14 F (2d) 178
(2) San Jose Canning Co. v. O'Neal 10 F (2d) 100
(3) 94 U. S. 780
(4) 1876 C. D. 430—92 U. S. 347
(5) International Mausoleum Co. v. Sievert 213 F 225
(6) 1923 C.D. 651—261 U.S. 24
(7) 223, 898 Edison, 2/2/80
(8) 1,018,502 Just and Hanaman, 2/27/12
(9) 1 Abbot 1—11 Coke R84-b (Case of Monoplies) 1602 A.D.
(10) 21 Jac. Ch. 3 (1623 A.D.)
(11) 191 F 350

Factory Designed to Prevent Espionage

Drafting room of Pioneer Engineering & Manufacturing Company's new plant exemplifies many features of the specially built, espionage and sabotage-proof building. Every drawing, print, and specification is checked in at night at a central file. Storage is in safes, combinations of which are known by only one person. Lockers besides drawing boards have no locks, eliminate central locker room. Engineer's desk is located where he can observe everyone entering or leaving the drafting room.

Building itself is a shell with 125-ft. roof trusses so that partitions can be freely changed. Catwalk through trusses above ceiling gives access to light and telephone wires. Only entrance to catwalk is by ladder which must be set up in a conspicuous spot in the main aisleway. Windows in plant, 2 x 2 ft. safety glass to guard against bombs thrown in from outside, are placed 6 ft. from floor. Information cannot be passed out through windows.

To prevent sabotage, all utilty intakes are overhead, carried to concrete vault under building. Only one person has key to metal door of this vault. Air conditioning units are located here. Air is distributed through ducts in truss space, and is returned to blowers through concrete tunnels underground.

Factory resembles an armory in outward appearance, and is surrounded by a fence with only one watchman's gate for all traffic. Visitors to plant enter building through only door into reception lobby. Receptionist electrically controls entrance doors to three major portions of plant. Visitors are announced throughout plant by amplifiers. Persons cannot go from one part of the building to another without getting the supervisors of each section to unlock doors between sections. Emergency exits are electrically opened from supervisors desks, eliminating necessity for guards.

PROTECTING DOCUMENTS

From Espionage and Sabotage

JOHN EDGAR HOOVER, *Director*
Federal Bureau of Investigation, United States Department of Justice

RECENTLY A SPECIAL AGENT of the Federal Bureau of Investigation conducted a survey of a manufacturing establishment engaged in supplying engines for the Army and Navy as well as for the British Government. "Yes, we are well supplied with vault and safe space for confidential plans and blueprints," said a high company official when interviewed by the Agent. The truth of this statement was borne out by the survey. The Tool Design Department was equipped with a large vault and the Engineering Department was adequately supplied with four strong safes.

While the official and the Agent were examining the equipment, the latter paused for a moment, stating, "Watch this." To the official's amazement the Agent opened the vault. He had found the combination scribbled in pencil on the door. But this was not all. A similar situation was found in each instance as the two men continued their tour of places of safekeeping for confidential plans and blueprints. The F.B.I. recommended to the plant management that the combinations to all vaults and safes be changed immediately and that the new combinations be furnished to as few plant officials and employees as was practicable.

This instance is typical of some of the laxities in the industrial world which have been brought to light through the extensive plant survey program which was undertaken by the F.B.I. in the fall of 1939, at the request of the War and Navy Departments. Already almost 2,000 key industrial facilities have been covered by the surveys and several hundred more are on the priority list awaiting immediate attention. Through this program industry has been apprised of weaknesses in its defensive armor, and all along the line many improvements have been made by the cooperative plant officials to safeguard their facilities against the thrusts of the spy and the saboteur. In making these surveys the F.B.I. is not concerned with legitimate labor relationships; its sole interest is in safeguarding American industry through appropriate recommendations to plant officials for improved protective facilities.

While each industrial establishment presents its own peculiar problems in the plant protection field, the safeguarding of such confidential items as blueprints and specifications is of unusual significance in any key industrial concern. Because of their physical properties these are easily concealed on the person and, of course, they are quickly consumed by fire. Any successful plan of protecting these confidential papers must be designed to guard against theft, destruction and copying.

In preventing theft, the first consideration is the integrity of the employees handling or having access to the documents. Shortly after a draftsman was discharged for inefficiency by an aircraft concern a few months ago, his wife delivered to her attorney some highly confidential plans pertaining to experimental planes which the former employee had in his possession when he stopped work. The plans had originally been charged to the draftsman by the Files Section of the company, and as a result of the lax charge-out system employed had remained in his possession for months. He was subsequently convicted in Federal Court under the Theft of Government Property Statute and sentenced to a term of six months in prison.

While the investigation of all plant employees is of great importance, it is urgent that particular attention be given to those engaged in confidential work. The inquiries should establish beyond doubt their character, reputation, patriotism, and previous employment record. It is suggested that the places where confidential items are kept be designated as restricted areas and that the number of employees having access to these be held to a minimum. The practice of breaking down blueprints into their component parts in such a way that it would be necessary for a foreign agent to acquire each part in order to have a complete set of the plans has been adopted in several plants working on extremely confidential items.

In considering the protection of blueprints and similar documents against destruction by accident, negligence or sabotage, the most important safety measure is a fireproof vault or safe for storage purposes. In one plant being surveyed the Special Agent noted that the vault was equipped with a standard combination fireproof door. It was learned, however, that the rear and side walls separating the vault from the factory proper consisted of wood partitions, thus making the repository neither fireproof nor secure.

It is recommended that duplicate sets of all valuable and irreplaceable blueprints, plans and specifications be maintained in another vault situated in a remote part of the plant. Because of the highly inflammable properties of items of this nature it is imperative that adequate fire fighting equipment be available in those areas where they are stored or where work is done in connection with them. The plant fire department and the city fire department should be informed of the location of these confidential items so that in case of a plant fire they could be salvaged first.

The necessity for honest and loyal employees is further seen when considering the possibility that confidential material might be released through copies of blueprints and specifications made either inside or outside the plant. The integrity of the employees themselves is the only protection against their drawing from memory complete sets of plans at their homes while off duty. Draftsmen should be held strictly accountable for all work papers. Then, too, workmen should not be permitted to make their own sketches on pieces of scrap paper, a practice followed at times by mechanics and other workers in American industrial facilities. When reproduction of blueprints and plans are made, it is suggested that a numbering system be utilized so that a record can be kept of each item. Unsatisfactory reproductions as well as work papers, carbon paper and waste papers pertaining to confidential documents should be disposed of carefully by burning or shredding them within the plant.

The success of the spy and the saboteur will be determined by their ingenuity. American industry, aided by law enforcement, must outsmart them. The methods of protecting confidential documents are without limit, and it is only through constant diligence in this regard that plant managements can hope to make their facilities secure.

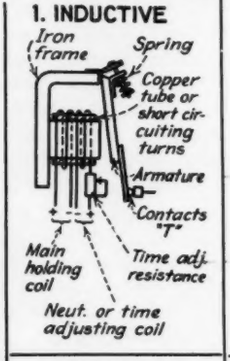
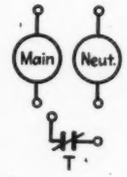
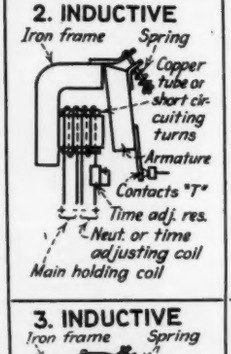
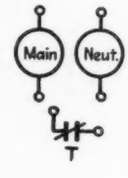
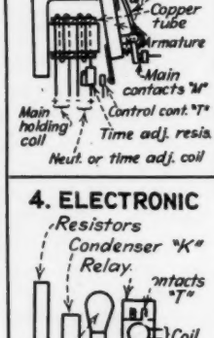
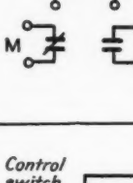
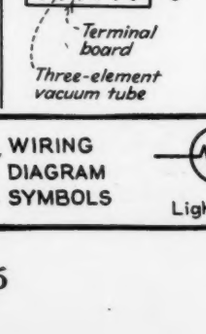
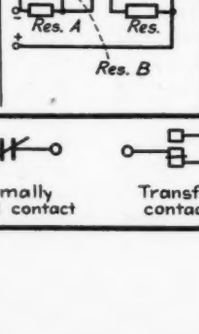
TIME DELAY RELAYS AND

R. B. IMMEL
Control Engineer, Westinghouse Electric & Mfg. Company

SELECTION of the most suitable timing device for the operation or control of machines and electric circuits is simplified by outlining the conditions under which the device is to operate. The frequency of operation, reliability, exactness of time delay period, adjustability of period, space available, and permissible cost are important factors.

In general, it may be said that for short time delay periods a device which operates upon the principle of stored energy is the simplest and most satisfactory type of device to use. It usually has a minimum number of parts and the time delay period will not change with use except through limitations in the life of mechanical parts. Inductive

DIRECT CURRENT OR ADD RECTIFIER FOR ALTERNATING CURRENT

Type of Time Delay Relay and Device	Principal Application	Principle of Operation	Wiring Diagram	Time Characteristics: Time Range / Uniformity of Period
1. INDUCTIVE 	Short time accelerating relay for steel mill control	After coils have been energized, time period may be initiated by opening or shorting main winding. Decay of magnetic field induces current in copper tube or short-circuits turns around core, which produces a sustaining magnetic force to hold armature closed. Magnitude of neutralizing current, which produces ampere turns opposing those of main coil, will determine the time period required to dissipate residual magnetism and permit release of armature at end of time period.		0.5 to 1.5 sec. Good Instantaneous reset Method of Time Period Control: Adjustment of neutralizing current and armature spring tension.
2. INDUCTIVE 	Long time accelerating relay for steel mill control	Operation is similar to (1). Longer time delay period is obtained by frame 250 percent larger in cross section area than (1). Time delay period is inversely proportional to reluctance of magnetic circuit.		1.5 to 4 sec. Good Instantaneous reset Method of Time Period Control: Adjustment of neutralizing current and armature spring tension.
3. INDUCTIVE 	Combination accelerating relay and contactor for general purpose, marine, and machine tool controllers	Operation is similar to (1). Addition of large contact makes possible use of relay as combination accelerating relay and contactor. Time delay period is also inversely proportional to resistance of tube or short circuited winding around core.		0.5 to 4 sec. Excellent Instantaneous reset Method of Time Period Control: Adjustment of neutralizing current.
4. ELECTRONIC 	Machine tool controllers and miscellaneous control	When control switch is closed, condenser will be charged since it is across potentiometer resistor *A*. Opening switch permits condenser to discharge through parallel resistor *B*. Negative potential on grid becomes steadily lower and, at a critical value, plate current increases sufficiently to operate relay. Condenser leakage causes inaccurate timing for periods over one minute.		0.05 to 60 sec. Exact Instantaneous reset Method of Time Period Control: Adjustment of condenser discharge resistor.

THEIR CHARACTERISTICS

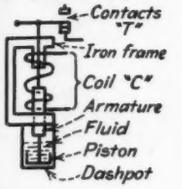
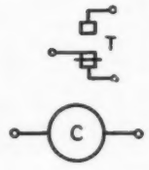
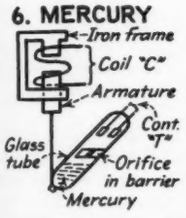
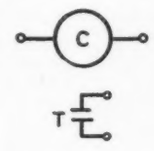
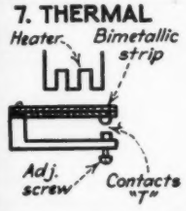
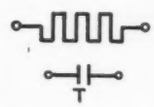
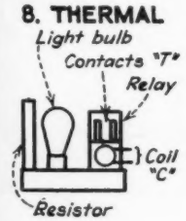
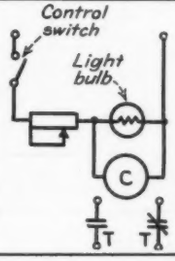
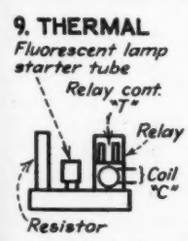
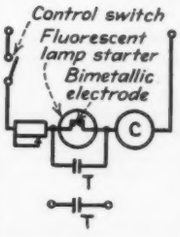
time relay and electronic timers are devices in which the time period is based upon the storage of electrical or magnetic energy.

Motor-driven mechanisms are usually used to obtain long time delay periods. The a.c. synchronous motor, which is readily adapted to drive this device, makes possible an exact time delay period.

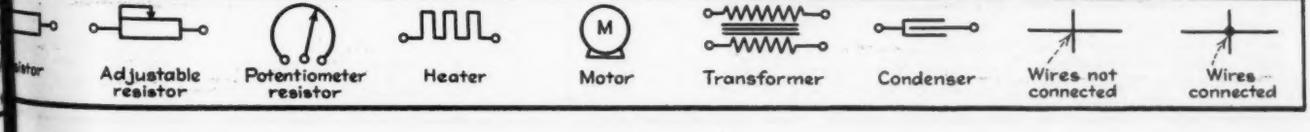
Thermal time delay devices usually cost less than the other types, but they must be applied only where an exact time delay period or a quick reset period is not required.

Many variations of each form of timing device are manufactured, but in general the principle of securing a time delay period is one of those tabulated. Every available device was designed for a specific application and deviations from standard applications are liable to result in unsatisfactory operation.

ALTERNATING AND DIRECT CURRENT

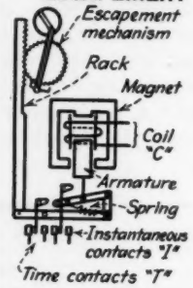
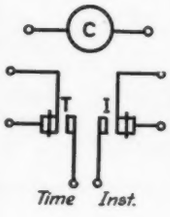
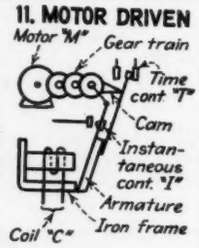
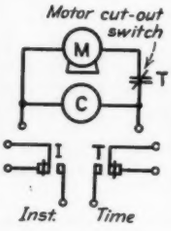
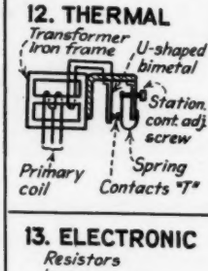
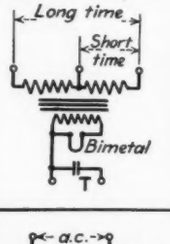
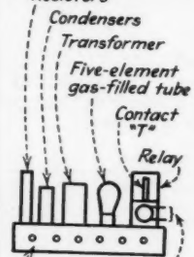
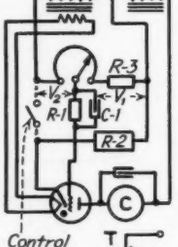
Type of Time Delay Relay and Device	Principal Application	Principle of Operation	Wiring Diagram	Time Characteristics: Time Range / Uniformity of Period
5. DASHPOT 	Transfer relay on automatic auto-transformer starters and general purpose control	Piston in dash-pot retards upward movement of armature when coil is energized. Size of adjustable by-pass orifice in piston determines time for fluid to flow through piston. A check valve in piston permits fast reset.		3 to 15 sec. Good Reset time: 2 sec. (approx.) Method of Time Period Control: Adjustment of orifice in piston.
6. MERCURY 	Machine tool and miscellaneous control	Energization of magnet tilts glass tube and permits mercury to flow through orifice. Time period is determined by rate of flow through orifice.		½ sec. to 3 min. Good Instantaneous reset Method of Time Period Control: Non-adjustable (size of orifice determines time).
7. THERMAL 	Starting control of hot cathode mercury vapor tube. Suitable only for infrequent operation	Heat generated by resistance type heater causes bi-metallic strip to deflect and close circuit after a time delay period. Thermal capacity of bimetallic strip also determines time period. Contacts have slow make and break action.		½ sec. to 10 min. Poor Reset time: 1–2 min. (approx.) Method of Time Period Control: Adjustment of bimetal travel and heat dissipation of heater.
8. THERMAL 	Experimental and test circuits	Hot filament resistance of tungsten filament lamp is many times cold filament value. When control switch is closed, voltage divides across resistor and bulb in proportion to their resistances. At start, a large proportion of voltage drop appears across resistor. After a short time delay, lamp resistance increases and its voltage drop is sufficient to operate relay.		1/60 to ½ sec. Poor Reset time: 15 to 30 sec. (approx.) Method of Time Period Control: Adjustment of resistor and selection of bulb wattage.
9. THERMAL 	Experimental and test circuits	Above a certain critical voltage, gas in fluorescent lamp starter tube conducts current and heats one of bimetallic electrodes. After time delay period proportional to glow discharge current, two electrodes contact each other and close relay coil circuit to operate relay.		½ to 15 sec. Fair Reset time: 15 to 30 sec. (approx.) Method of Time Period Control: Adjustment of glow discharge current resistor.

(*continued on next page*)



TIME DELAY RELAYS *(continued)*

ALTERNATING CURRENT

Type of Time Delay Relay and Device	Principal Application	Principle of Operation	Wiring Diagram	Time Characteristics: Time Range / Uniformity of Period
10. MECHANICAL ESCAPEMENT 	Timing relay in reduced voltage motor controllers for transferring from low to high voltage at end of time period	Energization of coil lifts armature to elongate tension spring. Stored energy in spring tends to lift lower lever arm, which is retarded by escapement mechanism. When pinion gear has been rotated sufficiently, rack teeth are disengaged and lower lever arm is free to move upwards and operate timed contacts. Addition of intermediate gear permits longer time period.		1 to 17 sec. Good Instantaneous reset Method of Time Period Control: Adjustment of period of balance wheel in escapement mechanism.
11. MOTOR DRIVEN 	Synchronous motor voltage and reduced voltage controllers. Particularly suited for long time delay periods	When relay coil and synchronous motor have been energized, instantaneous relay contact is operated and gear train is engaged to motor pinion gear. Operation of gear train rotates cam and permits time contact to close after time delay. Gear train is usually disengaged upon de-energization of circuit to permit quick resetting.		1 sec. to ∞ Exact Reset time: 1 sec. (approx.) Method of Time Period Control: Shifting of gears and setting of tripping cam.
12. THERMAL 	Used in reduced voltage and capacitor motor controllers. Suitable only for infrequent control operations	The U-shaped bimetallic strip carrying moving contact is heated by secondary current of transformer. Deflection of bimetal closes circuit after time delay period. Stationary contact is also mounted on bimetallic strip to compensate for ambient temperature.		2 to 15 sec. Fair Reset time: 30 to 60 sec. (approx.) Method of Time Period Control: Adjustment of bimetal travel and tap setting on transformer primary.
13. ELECTRONIC 	Welding, machine tool, molding machine, and sign flasher controllers. Also used for photographic timing. Particularly suitable for continuous timing cycle applications	With control switch open, condenser *C*-1 is charged to potential *V*-1 by one-half wave rectification. Time period is initiated by closing control switch, which applies transformer voltage directly to tube. Voltage *V*-1 across condenser *C*-1 is greater than *V*-2, hence grid is negative and prevents current from flowing in tube. As condenser discharges through resistance *R*-1, *V*-1 decreases and tube permits current to operate relay coil *C* when *V*-1 is less than *V*-2.		0.05 to 60 sec. Exact Reset time: 2 sec. (approx.) Method of Time Period Control: Adjustment of voltage V-1 by potentiometer resistance.

Current and Power Ratings, Dimensions and Costs

	Type of Time Delay Relay and Device	Ampere Contact Rating (Approx.) 220v.	Ampere Contact Rating (Approx.) 600v.	Watts Actuating Burden (Approx.)	Typical Dimensions Inches: Height	Width	Depth	Relative Cost Index
D.C. or add rectifier for A.C.	1. Inductive	3	3	25	6	4	5	250
	2. Inductive	3	3	40	8	5	6	400
	3. Inductive	5 Aux. Cont. 300 Main Cont.		40	7	5	6	400
	4. Electronic	3	..	100	7	5	5	600
A.C. and D.C.	5. Dashpot	5	5	70	8	4	4	300
	6. Mercury	5	..	10	5	3	3	150
	7. Thermal	5	5	10	4	4	3	100
	8. Thermal (light bulb)	5	..	50	8	6	4	75
	9. Thermal (fluorescent lamp starter tube)	5	..	15	6	4	3	75
A.C.	10. Mechanical Escapement	10	10	50	8	5	7	400
	11. Motor Driven	10	10	15	6	6	6	400
	12. Thermal	5	5	10	3	3	5	150
	13. Electronic	3	..	15	7	5	5	300

SPRING STEELS – II

Data Required for Selection

HAROLD CARLSON
Lee Spring Company, Inc.

TO BRING existing data and results of new findings pertinent to spring steels up-to-date, and to arrange such information so that engineers, designers, and others who design springs or specify spring steels may have easy access to it for reference purposes, this article covers all the important basic types and compositions of spring steels. Part I, published in PRODUCT ENGINEERING for January, explained the effects of alloying elements on spring steels, gave general background data on wire manufacture, briefly discussed methods for increasing strength and life of springs, and gave a broad comparison of all types.

Specific information, paralleling that given in this part, was presented for hard-drawn steel spring wire in Part I. Design data for two other basic spring steel alloys are presented here. Reference is made in this article to several A.S.T.M. Specifications ending with numerals "41." These were 1939 Tentative Specifications until adopted as standard late in 1941, and can be found listed as such in existing A.S.T.M. publications. Part III, next month, will conclude the series.

Music Wire Spring Steel

MUSIC WIRE is the best quality cold-drawn, high carbon, spring steel obtainable. It has exceptionally high strength, uniformity, and temper, and is used for the great majority of springs requiring wire diameters up to ⅛ in. This type of wire is frequently called "piano wire" but the name "music wire" is more generally acceptable. The names are derived from the application of this wire to stringed instruments, especially the piano. The color of the wire is similar to clean, polished steel with a bright lustrous finish and is obtained by drawing the wire through a liquid tin solution prior to the last pass through the drawing die, thus depositing a very thin coating of tin on the surface of the wire. This finish is standard for all music wire. It is much too thin to act as a good rust-resistant coating, but it does keep the surface sufficiently clean so that electro-plated finishes such as cadmium can be applied directly without acid dipping.

MANUFACTURE. Music wire of excellent quality and high tensile strength combined wtih good ductility can be obtained exactly to size desired from Sweden in normal times. Excellent music wire comparing favorably with that produced in Sweden is made in the United States from imported Swedish steel rods. Due to the difficulty encountered in obtaining Swedish steel at this time, it is necessary to manufacture music wire from domestic steel. Such steel is made by the acid open-hearth or electric-furnace process and although of good quality, it does not equal the Swedish steel in uniformity, tensile strength, or ductility. Music wire, like "18-8" stainless steel, phosphor-bronze and hard-drawn wire, obtains its tensile strength and hardness from cold-drawing. It is essentially a hard-drawn wire. The smaller sizes are drawn through dies made of drilled diamonds and sapphires.

APPLICATION. Music wire spring steel is the best, toughest, and most widely used material for all types of small springs subjected to high stresses, frequent deflections and suddenly applied loads. It may be obtained readily in many gage sizes as each wire manufacturer draws it to the gage best suited to his drawing practice. The wire diameter, like all other spring wire, should be specified to three decimal places. The most popular sizes run from 0.005 in. to 0.125 in. dia., but some manufacturers on special order will supply it in an assortment of sizes from ⅛ to $\frac{7}{16}$ in. dia. Square and rectangular wire is not commercially available. Although this steel is tough and durable, springs made from it should not be subjected to temperatures exceeding 250 deg. F. At that temperature, springs will suffer a load loss of approximately 5 percent when stressed to 100,000 lb. per sq.in. and this loss increases rapidly in higher temperatures.

CHEMICAL COMPOSITIONS. There are two or three so-called standard specifications for music wire (Table V), but each has one or two features that need changing. All S.A.E. specifications for this type of wire permit too much manganese, phosphorus and sulphur. A.S.T.M. A228-41, which is a specification recently adopted, has too wide a carbon content range and starts at 0.70 percent which is too low for this type of wire. Although it is a fairly good general composition, it has tensile strength values giving too much leeway for exacting requirements. In general, carbon on the high side of the ranges listed is used for the larger wire sizes and on the low side for the fine sizes. Special No. 1 and No. 2 are recommended in preference to the others, especially for Swedish steels. Music wire made from domestic steel will have slightly more phosphorus and sulphur than the Swedish steel.

Other chemical compositions similar in every respect to those listed except for carbon content, have the following carbon ranges: 0.75 to 0.85, 0.90 to 1.00, and 0.95 to 1.05 percent.

TENSILE STRENGTH. Music wire acquires its tensile strength through the

Table V—Composition of Music Wire

(Percent)

Composition	Special No. 1	Special No. 2	S.A.E. 1085	A.S.T.M. A228-41
Carbon	0.80–0.90	0.85–0.95	0.80–0.95	0.70–1.00
Manganese	0.25–0.35	0.25–0.45	0.60–0.90	0.20–0.60
Silicon	0.15–0.25	0.15–0.30	.....	0.12–0.30
Phosphorus	0.025 Max.	0.025 Max.	0.040 Max.	0.030 Max.
Sulphur	0.025 Max.	0.025 Max.	0.055 Max.	0.030 Max.

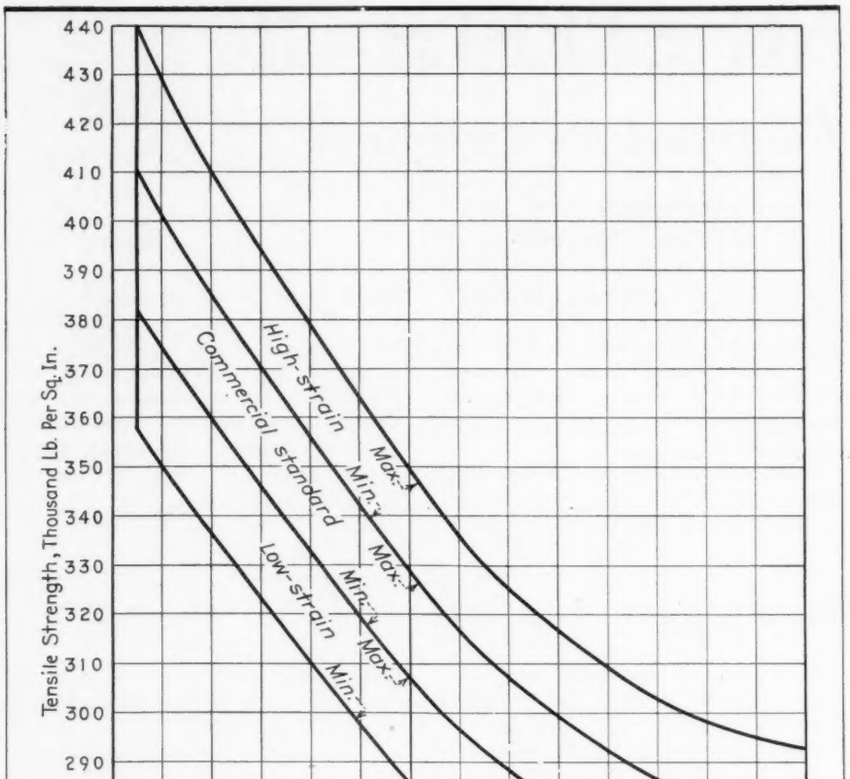


Fig. 2—Tensile strength of music wire spring steel

cold work performed on it when drawn through the drawing dies. The reduction of area per pass and number of passes through the dies determines the wire size and hardness in addition to the tensile strength. Each wire manufacturer has his particular method of wire drawing and although all methods are very similar, no two companies produce wire exactly alike, nor will two batches of wire of the same diameter and chemical composition made by any one company by the same method, produce wire with exactly the same tensile strength. Most wire manufacturers make one type of music wire conforming to one set of tensile strength values. Others produce two, three and as many as four grades, all with the same chemical composition. It is exceptionally difficult to determine the exact tensile strength of wire within 10,000 lb. per sq.in., especially on the fine sizes. For this reason, it is preferable to have three standards or tensile strength ranges. In drawing a wire of about 0.030 in. dia. to a desired tensile strength of 360,000 lb. per sq.in., it might actually come out with only 340,000 lb. per sq.in. or as high as 380,000 lb. per sq.in. For practical purposes, each of the three wires has some particular advantages over the others. The wire with the lower tensile strength will have less hardness, greater ductility, and will be especially suitable for springs subjected to flexural stresses such as torsion springs and rings, and for springs requiring sharp kinks or bends and where the spring outside diameter divided by the wire diameter is less than five. For all general springs the 360,000 lb. per sq.in. wire is best. For springs subjected to abnormally high stresses the 380,000 lb. per sq.in. wire will have the highest fatigue life provided the spring outside diameter divided by the wire diameter is larger than seven.

There are three definite ranges of desirable tensile strengths as shown in the tensile strength curves, Fig. 2. Spring drawings should either specify the type of music wire desired or leave it to the discretion of the spring manufacturer. Music wire is always purchased to a tensile strength range rather than by a commercial designation or trade name. Thus, if wire of 0.060 in. dia. is desired for general use, it should be ordered to a tensile strength taken from the curves as follows: 307,000 min. to 329,000 lb. per sq.in. max. For "low-strain" wire it should be ordered 286,000 min. to 307,000 lb. per sq.in. max., and for "high-strain" wire, it should be ordered 329,000 min. to 350,000 lb. per sq.in. max. The curves in Fig. 2 were made up from data received from several wire drawing companies and it is hoped that these three ranges will become a standard for all. At the present time, the A.S.T.M. A228-41 specification tensile strength recommendations vary over a wide range permitting too much leeway for

Table VII—Music Wire Tolerances

(A)—Average of Manufacturers

Wire Dia., In.	Plus or Minus, In.
Up to 0.016	0.00025
0.0165 to 0.032	0.0003
0.0325 to 0.063	0.0005
0.0635 to 0.100	0.0008
0.101 to 0.125	0.001
0.126 to 0.140	0.0015
Over 0.140	0.002

(B)—A.S.T.M. A228–41

0.026 and under	0.0003
0.027 to 0.063	0.0005
0.064 and over	0.001

Table VI—Physical Properties of Music Wire

Elastic Limit in Tension; Percent of Tensile Strength	60 to 75 percent
Elastic Limit in Torsion; Percent of Tensile Strength	45 to 50 percent
Modulus of Elasticity in Tension E	30,000,000
Modulus of Elasticity in Torsion G	Up to 0.100 in. dia., 12,000,000
Modulus of Elasticity in Torsion G	Over 0.100 in. dia., 11,750,000
Hardness, Rockwell C, over 0.100 in. wire dia	42 to 46
Weight, lb. per cu. in	0.284 lb.
Elongation in 2 in., approx	8 percent

exacting requirements. Army and Navy specifications are so indefinite in this respect that inferior grades of wire meet their requirements.

PHYSICAL PROPERTIES of music wire are listed in Table VI. All music wire up to ⅛ in. dia. can be bent around an arbor equal to the wire diameter, without breaking or cracking the surface. (All diameters over ⅛ in. are special.)

TOLERANCES. Each wire manufacturer has his own wire drawing limits and tolerances. Table VII (A) lists the tolerances that may be expected on commercial wire and which is a fair representation of those acceptable to the trade. Table VII (B) shows the tolerances recommended by A.S.T.M. A228-41, but these are far too large to permit exacting work.

PRICE. The average price in 1940, in quantities of 50 to 100 lb. for commercial standard music wire varied considerably depending upon the wire diameter as shown in the table.

The cost per pound varies in accordance with the quantity ordered, wire size and tensile strength. A small quantity of fine wire becomes quite expensive; ten pounds of 0.10 in. dia. wire may cost about $1.50 per lb. Low-strain wire runs about 10 to 20 percent less, and high-strain wire about 10 to 20 percent more than the price shown in the table.

Wire Dia., In.	Price Per Lb.
Under 0.020	45 to 80 cents
0.021 to 0.030	30 to 45 cents
0.031 to 0.079	20 to 30 cents
0.080 to 0.312	17 to 20 cents

Oil-Tempered Spring Steel Wire

OIL-TEMPERED SPRING WIRE is a good quality, cold-drawn. high-carbon spring steel, uniform in quality and temper, used for the great majority of springs requiring wire sizes of ⅛ to ½ in. dia. The color of the wire is a dull, smoky black lacking all lustre and sheen. Springs made from this wire are generally coated with black japan to improve the appearance of the wire and retard corrosion. Other finishes including cadmium and zinc are also used.

MANUFACTURE. This steel is made by the basic or acid open-hearth and electric-furnace process from domestic ores. Wire to be oil-tempered is first cold-drawn to the desired size from annealed rods and then heat-treated by the "continuous-draw" method. In this process, the wire is pulled through a molten lead bath where it is heated to the proper quenching temperature, then through oil for quenching, then through another lead bath for tempering. Variations in the heat-treatment temperatures and drawing time through the baths are closely regulated to produce wire with the correct hardness and tensile strength.

APPLICATION. Oil-tempered spring steel wire is a general purpose steel, commonly used for all types of coil springs where the stress range is not too high and where the springs are not subjected to continuous shock or impact loadings. It may be obtained readily in many gage sizes (Washburn & Moen preferred) from 0.028 to ½ in. dia. Square, rectangular, and round wire rolled into rectangular shapes with round edges are obtainable on special order. This type of wire is especially recommended for springs requiring wire diameters over ⅛ in. and up to ½ in. Springs made from this steel may be used in temperatures up to 350 deg. F. with less than 5 percent loss of load, if stressed under 60,000 lb. per sq.in. and heated to 650 deg. F. after coiling.

Oil-tempered wire may be obtained also in the annealed or untempered condition. It is often necessary to design springs with sharp bends or kinks, particularly those springs of the torsion type or which require that the ratio of the outside diameter of the spring divided by the wire diameter equal less than five. For these springs, the annealed wire is suitable. Such springs require heat-treatment to harden and temper them after coiling and, of course, are more expensive; in the case of extension springs, they cannot be wound with initial tension. Whether or not such springs should be made of oil-tempered wire or annealed wire is as much a problem of spring manufacture as one of design. Most designers of springs would do well to leave this problem to the spring manufacturing companies.

CHEMICAL COMPOSITIONS. There are several standard specifications in existence for oil-tempered wire and several ranges of carbon content. Table VIII lists some of these. The one most generally known, produced more often and in larger quantities with the best uniformity and recommended for all oil-tempered steel springs, is S.A.E. X1065. The compositions containing higher carbon content than this specification are sometimes requested by a few designers who feel that the higher carbon content produces a better spring. Whether or not a larger amount is preferable is questionable. For wire diameters over ⅜ in., a higher carbon content is desirable; for smaller sizes, it is not. Most wire producers furnish the larger wire sizes with the carbon content on the high side of S.A.E. X1065 and the smaller sizes on the low side.

A.S.T.M. A229-41 is made in two compositions. Grade A is recommended for wire sizes $\frac{3}{32}$ in. dia. and larger. Grade B is for sizes less than $\frac{3}{32}$ in. dia. A.S.T.M. A230-41 is a specification for valve spring wire. The only differences between valve spring wire and other oil

Table VIII—Compositions of Oil Tempered Spring Wire

(A)—S.A.E. SPECIFICATIONS
(Percent)

Composition	S.A.E. X1065	S.A.E. 1080	S.A.E. 1905
Carbon	0.60–0.75	0.75–0.90	0.90–1.05
Manganese	0.90–1.20	0.60–0.90	0.25–0.50
Phosphorus	0.040 Max.	0.040 Max.	0.040 Max.
Sulphur	0.055 Max.	0.055 Max.	0.055 Max.

(B)—A.S.T.M. SPECIFICATIONS
(Percent)

Composition	A.S.T.M. A229–41 Grade A	A.S.T.M. A229–41 Grade B	A.S.T.M. A230–41 Valve Spring Wire
Carbon	0.55–0.75	0.55–0.75	0.60–0.70
Manganese	0.80–1.20	0.60–0.90	0.50–0.80
Silicon	0.10–0.30	0.10–0.30	0.12–0.30
Phosphorus	0.045 Max.	0.045 Max.	0.030 Max.
Sulphur	0.050 Max.	0.050 Max.	0.030 Max.

Table IX—Tensile Strength of Oil-Tempered Wire

(lb. per sq. in.)

Wire, Dia., In.	Group *A*		Group *B*		Group *C* (A.S.T.M.)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
0.032	278,000	295,000	281,000	311,000	275,000	310,000
0.035	270,000	290,000	276,000	306,000	268,000	303,000
0.041	265,000	285,000	270,000	295,000	261,000	296,000
0.047	260,000	280,000	263,000	288,000	254,000	289,000
0.054	255,000	275,000	257,000	282,000	248,000	283,000
0.0625	250,000	270,000	251,000	276,000	242,000	277,000
0.072	245,000	265,000	245,000	265,000	236,000	271,000
0.080	240,000	260,000	240,000	260,000	230,000	265,000
0.092	235,000	255,000	235,000	255,000	225,000	260,000
0.105	230,000	250,000	229,000	249,000	220,000	255,000
0.120	225,000	245,000	222,000	242,000	215,000	250,000
0.135	220,000	240,000	219,000	239,000	210,000	240,000
0.148	215,000	235,000	215,000	235,000	205,000	235,000
0.162	210,000	230,000	212,000	232,000	200,000	230,000
0.177	205,000	225,000	210,000	230,000	195,000	225,000
0.192	200,000	220,000	206,000	226,000	190,000	220,000
0.207	195,000	215,000	204,000	224,000	185,000	215,000
0.244	190,000	210,000	197,000	217,000	182,000	212,000
0.250	188,000	208,000	195,000	215,000	180,000	210,000
0.3125	185,000	205,000	188,000	208,000	178,000	208,000
0.375	180,000	200,000	185,000	205,000	175,000	205,000
0.4375	177,000	197,000	180,000	200,000	170,000	200,000
0.500	175,000	195,000	175,000	195,000	165,000	195,000

*A.S.T.M. Values shown in Group *C* have a further limitation: A single lot shall not vary more than 30,000 lb. per sq. in. in sizes of 0.120 in. and smaller, nor more than 25,000 lb. per sq. in. for sizes coarser than 0.120 in.

Table X—Physical Properties of Oil-Tempered Wire

Elastic Limit in Tension, Percent of Tensile Strength	
Up to 0.250 in. dia.	85 to 90 percent
Over 0.250 in. dia.	80 to 85 percent
Elastic Limit in Torsion, Percent of Tensile Strength	
Up to 0.250 in. dia.	45 to 50 percent
Over 0.250 in. dia.	40 to 45 percent
Rockwell Hardness, *C* Scale	
Up to 0.125 in. dia.	45 to 50
0.126—0.250 in. dia.	42 to 48
0.251—0.500 in. dia.	40 to 45
Elongation	
Up to 0.125 in. dia.	2.5 to 4.5
0.126—0.250 in. dia.	3.5 to 5.0
0.251—0.500 in. dia.	4.0 to 5.0
Modulus of Elasticity, in Tension, *E*	28,500,000
Modulus of Elasticity in Torsion, *G*	11,200,000
Weight, lb. per cu. in.	0.284 lb.

tempered wire are (1) the impurities, phosphorus and sulphur, are a little better controlled and limited to 0.030 percent maximum, (2) the wire is heat-treated in a controlled atmosphere furnace to give a very smooth surface to the wire so that the slight amount of surface scale ordinarily present on regular oil-tempered wire is absent, thus eliminating the trouble caused by scale clogging valves and moving parts in valves and motors, (3) it is reputed to have a slightly higher stress range and fatigue life characteristics due to the smooth surface, but the extra cost does not warrant its use for this one consideration for its increase in these properties is quite small.

TENSILE STRENGTH. Each wire manufacturer furnishes oil-tempered steel wire to the tensile strength he finds most suitable with his equipment. All are within limits that are useful for springs, some more so than others. Three groups are shown in Table IX. Most wire will be within the limits of groups *A* and *B*. Group *C* contains the requirements of A.S.T.M. A229-41 and is recommended for general specifying requirements.

PHYSICAL PROPERTIES. In addition to properties shown in Table X, oil-tempered wire up to ¼ in. dia. can be bent around an arbor equal to the wire diameter; ¼ in. dia. and larger can be bent around an arbor equal to twice the wire diameter without breaking or cracking the surface. This does not mean, however, that springs should be coiled about such small diameters, but is merely an indication of the bending qualities of the wire.

TOLERANCES. Cold drawn, oil-tempered steel wire may, when necessary, be obtained with small tolerances on the wire diameter. One manufacturer furnishes material in accordance with tolerances shown in Table XI (A). The A.S.T.M. tolerances as shown in Table XI (B) are in more general use, although they permit too much leeway for exacting work. A general rule is "up to ¼ in. dia., ± 0.001 in.; over ¼ in. dia., ± 0.002 in." Any out-of-roundness should always be within one-half of the total wire diameter tolerances.

PRICE. An average price in 1940 for S.A.E. X1065 in sizes up to ½ in. dia. in the cold-drawn, oil-tempered condition, in quantities of 500 to 1,000 lb., ran from 6 to 10 cents per lb. depending on wire size, the smaller sizes costing slightly more than the larger. The same wire annealed, and tempered square wire, costs about 10 to 20 percent more.

HEAT-TREATMENT. Springs made from oil-tempered steel are usually heated after coiling from 400 to 550 deg. F. to relieve coiling stresses. For use in elevated temperatures, they should be heated to 650 deg. F. If made from annealed steel, they should be heated to from 1,450 to 1,550 deg. F. (1,500 deg. F. preferred), quenched in oil and tempered at 475 to 575 deg. F. Extension springs wound with initial tension will lose from 25 to 50 percent of their initial tension when heated to 500 deg. F. after coiling.

Table XI—Oil-Tempered Wire Tolerances

(A)—MANUFACTURER'S

Wire Dia., in.	Tolerance, in.
Up to 0.062	+0.0005
0.063 to 0.135	+0.00072
0.136 to 0.250	+0.001
0.251 and up	+0.0015

(B)—A.S.T.M.

Up to 0.072	±0.001
0.073 to 0.375	±0.002
0.376 and up	±0.003

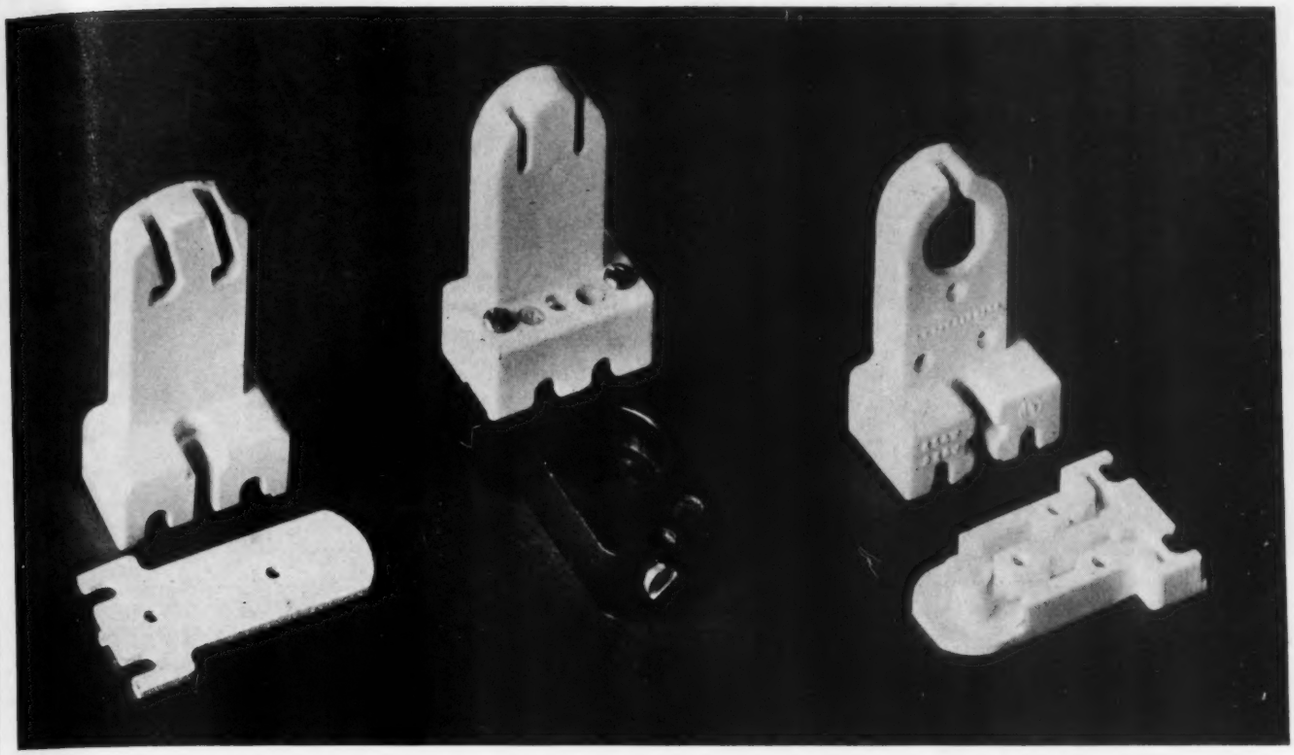


Fig. 1—Molded urea-formaldehyde tombstone fluorescent tube sockets are characterized by their mechanical strength, electrical strength and unobtrusive neutral white color

UREA PLASTICS

M. H. BIGELOW
Plaskon Company, Inc.

STRIKING CHARACTERISTICS of urea-formaldehyde resins are translucency, attractive depth of color, many colors available, and good electrical properties. These characteristics make urea plastics, although they cost nearly twice as much as black or brown phenolic molding compounds, the best choice for a growing field of uses, principal among which are lighting fixtures, machine housings and products where appearance is a primary consideration, and many electrical parts. Urea resin adhesives also have many advantages over other glues, particularly for high-strength, water-resistant plywood.

Urea resins are produced by reacting urea with formaldehyde, continuing the process by means of appropriate chemical control until the desired degree of polymerization has taken place. Urea itself is synthesized from ammonia and carbon dioxide. The suitability of urea resins for various applications is closely dependent upon the type and extent of polymerization.

Urea molded plastics are durable and mechanically strong. They are unaffected by water, oils, greases, and organic solvents. Their physical properties are listed in Table I. Ureas are thermosetting in nature, and consequently do not deform when heated. However, like all organic substances, they are subject to decomposition if heated to high temperatures. Nevertheless they may be used without restrictions at temperatures below 170 deg. F. and suffer no effects if intermittently exposed to higher temperatures (245 deg. F.) At temperatures above 170 deg. they gradually become brittle, more opaque, and lose color stability. In most cases where high temperatures are encountered the molded article can be designed to overcome this effect.

UREA MOLDING COMPOUNDS

Forms available	Fine powder, granules
Molding qualities	Excellent
Molding temperature	290–320 deg. F.
Molding pressure	1,500–6,000 lb. per sq. in.
Compression ratio	2.5–3.0
Mold shrinkage	0.006–0.011 in. per in.
Colors	Unlimited from natural colorless to black

Typical of applications involving continuous exposure to a high degree of radiated heat, are plastic reflectors for modifying the light output of incandescent lamps. Utilizing the known upper heat limitation of urea plastics, and the heat radiation of various wattage lamps, curves are available showing safe operating positions of semi-indirect reflectors.

Urea plastics absorb little visible light and make highly efficient lighting reflectors. These may vary from 6 to 28 in. in diameter. The number of varieties

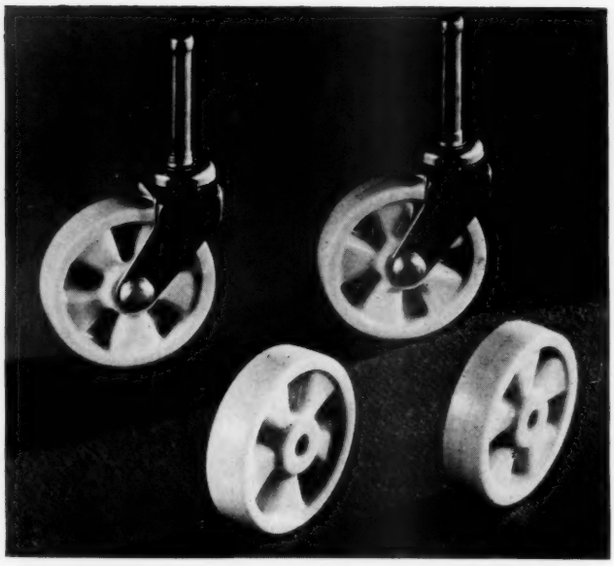


Fig. 2—Molded urea-formaldehyde casters show adaptability of strength, abrasion resistance, and oil resistance of urea plastics to mechanical parts

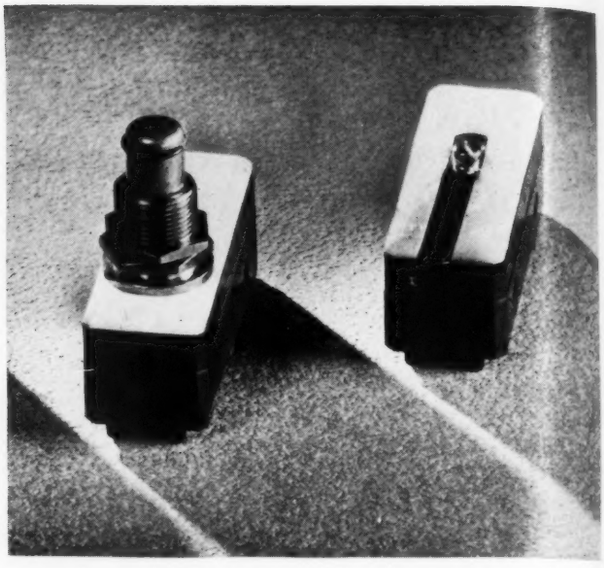


Fig. 3—Colored compounds of urea-formaldehyde are molded into these Micro Switch housings, combining good electrical properties of urea resins with ability to hold close dimensions

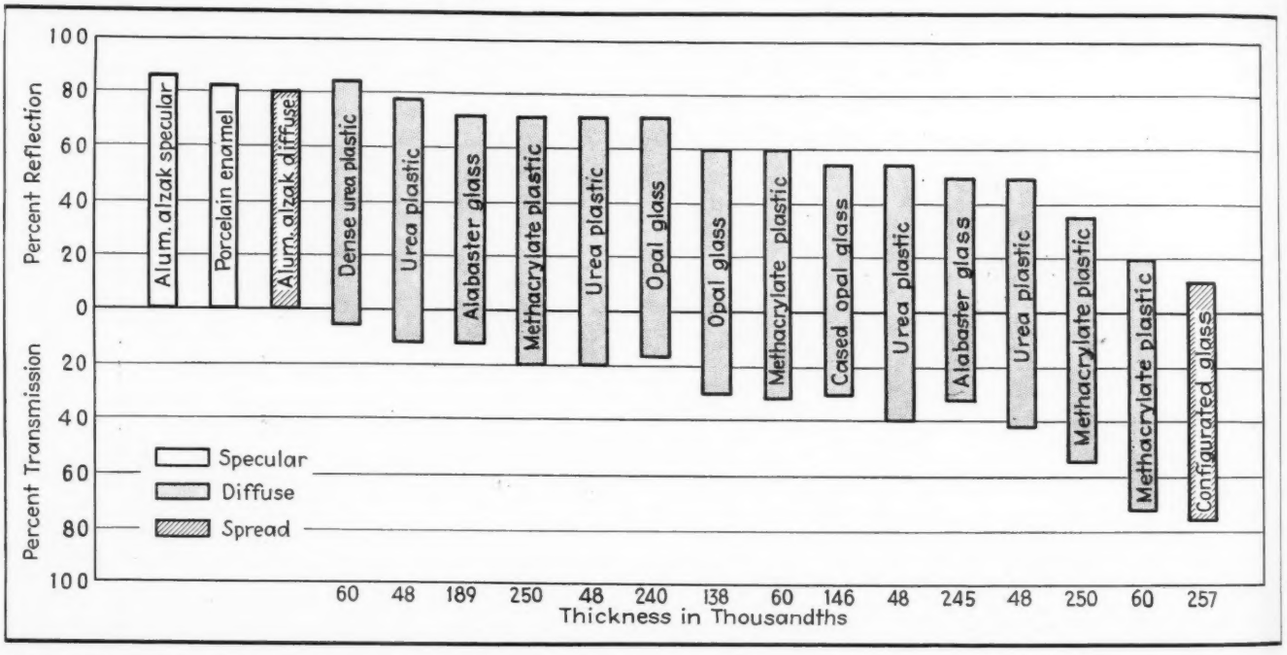


Fig. 4—Comparison of optical properties of urea-formaldehyde resins with those of other materials used in lighting reflectors

available commercially is large. In every instance their efficiency is well above 80 percent, an improvement over materials formerly used. Compared with glass, urea molded parts weigh only half as much, are not as breakable, and permit greater variations in design.

Urea plastics may be varied in optical density from translucent naturals to opaque whites. Even these colors can be modified to yield pleasing daylight effects with little reduction in efficiency. Fig. 4 indicates the comparison of the optical properties of urea plastics with other common luminaire materials.

While urea plastics have long been known for their unlimited color range and durability, they are now recognized also for their good electrical properties, particularly where resistance to arcing and tracking is important. These properties are indicated in Table III. When arcing occurs over a urea resin surface, the heat decomposes the resin but does not create a carbonized track as it does with phenolic resins. Therefore, resistance to arcing remains nearly the same for ureas but is reduced for phenolics by the track after the first arc flash.

Urea molded plastics are unaffected by light and are odorless, tasteless and non-toxic. These several properties combined with those mentioned in the foregoing tables make urea-formaldehyde plastics suitable for buttons, instrument housings, business machine housings, lighting devices, closures, electrical items, tableware, kitchenware and hardware.

Effect of moisture on urea molded parts is to cause slight swelling, which may cause cracks to appear at abrupt changes of section when the part is alternately subjected to extreme moisture and dryness. Laboratory tests

Table I—Physical Properties of Molded Urea Plastics

Specific gravity	1.45–1.50
Specific volume	19.1–18.5
Tensile strength, lb. per sq. in.	5,000–13,000
Modulus of elasticity, *E*, (tension) lb. per sq. in.	1,550,000–1,650,000
Compression strength, lb. per sq. in.	24,000–35,000
Flexural strength, lb. per sq. in.	10,000–15,000
Impact strength, ft. lb. per in. of notch, ½ x ½ in. bar	0.28–0.32
Hardness	
Brinell (500 kg., 10 mm.)	48–54
Rockwell	*M* 110–*M* 130
Scratch (Moh's scale)	3

Table II—Thermal Characteristics of Urea Plastics

Softening Point	None
Distortion temperature, deg. F	260–280
Tendency to cold flow	None
Thermal conductivity, 10^{-4} cal. per sec. per sq. cm. per deg. C. per cm.	7.1
Specific heat, cal. per deg. C. per gram	0.4
Burning rate	Chars; does not support combustion

often are made on a newly designed part and may indicate modifications in the design or molding process that are necessary to eliminate cracking caused by moisture.

Urea Resin Adhesives

In addition to molding compounds, urea-formaldehyde resins are available as water-proof adhesives. The history of industrial adhesives began with animal and vegetable glues—ill-smelling mixes that had to be soaked overnight. The development of casein glues next brought new life to the veneering industry with a powder that simply had to be mixed with cold water. But the first adhesives to give a permanently stronger-than-wood bond did not arrive until comparatively recently, when research produced dry-film phenolic resin glues. The new resin adhesive was waterproof, required no messy glue pots, yet was a good quick-acting, hot press bonding agent. Plywood, formerly a material which was certain to delaminate in damp places, became suitable for uses that were too severe even for seasoned lumber. Chief problems of the phenolic glues were the necessity for careful control of the moisture content of the wood prior to gluing and the after-conditioning required.

Thus urea adhesives were developed. They can be applied to wood containing up to 15 percent moisture, and require no special treatment after gluing. They have high strength, both in dry bond and wet bond. Strength tests are always accompanied by a high percentage of wood failure, as shown in Fig. 5. The urea glues have high resistance to cold water and warm water up to 180 deg. F. Cold setting glues supplied in two parts, and modified urea glues have good resistance to hot water above 180 deg. F. Resistance of all types to mold and fungus is high, and exterior durability is good.

Urea adhesives are divided into three general types: cold press adhesives, hot press adhesives, and special forms suitable for meticulous operations such as the manufacture of formed plywood for aircraft and other uses. Properties of the various types in common use are shown in Table IV.

Urea glues are sold in two forms: one where the hardener is sold separately and must be added to the mix just before the spreading operation, the other where the hardener is incorporated in the glue as a component part, or ready-mixed. Once the hardener is added there is a definite working life for the mix, after which it is so far polymerized that it jells or sets up. Many industries prefer the two-part glue. A day's batch of this can be

Table III—Electrical Properties of Urea Plastics

Dielectric strength, volts per mil	650–720
Dielectric constant	
60 cycles	7.6–8.6
10^6 cycles	6.6–7.7
Power factor	
60 cycles	0.040–0.055
10^6 cycles	0.027–0.035
Volume resistivity, Ohm-cm.	10^{12}–10^{13}
Arc resistance	Excellent
Tracking	None

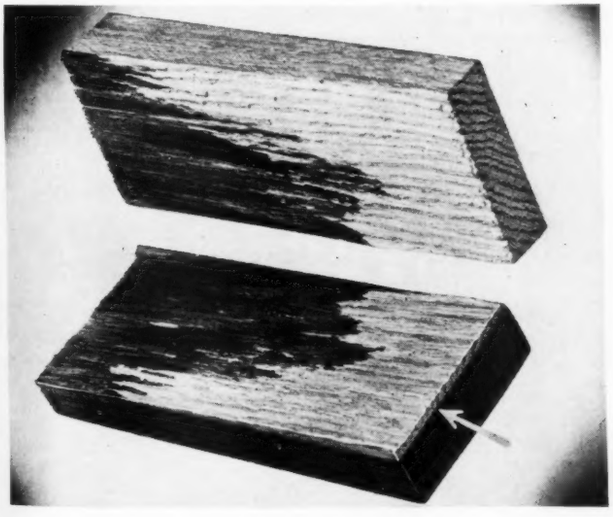


Fig. 5—Shear test block of bond of urea-formaldehyde adhesive shows characteristic wood failure at glue line

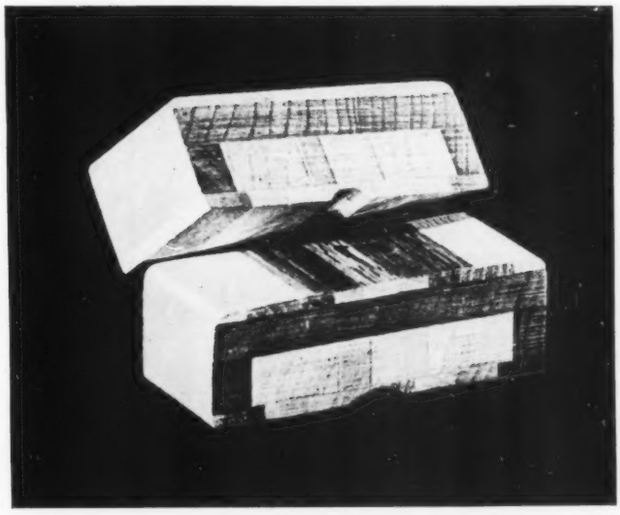


Fig. 6—Section through Flexible Flier ski showing laminated wood strips permanently bonded together with urea-resin glue

mixed, and the proper amount of hardener can be added to proportionate parts of the mix as required throughout the day. Where large batches are seldom demanded, the ready-mixed is generally preferred.

Urea glue lines are practically colorless. In some industries where maximum physical properties are required and where a single failure to incorporate hardener would endanger reputation and life, such as in aircraft manufacture, the hardener is tinted with a dyestuff which enables visual inspection and supervision of the final assembly.

Urea Protective Coatings

Although urea resins by themselves give films which are brittle, have poor adhesion and craze, urea resins used in conjunction with other organic film-forming materials make good quick-drying weather-resistant finishes for steel surfaces such as automobile body panels. In these finishes, urea resins are plasticized by alkyd resins and are combined with other ingredients to form enamels. Characteristic types are:

Urea resin-alkyds modified with unsaturated oils or acids produce baking finishes highly resistant to discoloration over long aging periods, as well as chemical resistance to fats, oils, solvents and other chemicals. Industrial applications of such a finish include refrigerators, household and hospital utensils and fixtures.

Urea resin-alkyds modified with unsaturated fatty acids and oils furnish excellent vehicles for automobile body, bicycle, and toy enamels. These enamels withstand rough usage and outdoor exposure.

Urea resins for enamels are available as butanol solutions containing 50 to 60 percent solids. They may be further thinned with aromatic hydro-carbons such as toluene and xylene.

Characteristics of all of these resins are shown in Table V.

Special Forms of Urea Resins

Other forms and uses of urea resins are known, but because of present war conditions their use is not commercially exploited except where indicated for National Defense. These include foamed urea resin, special dry coating material, resin for laminated high-impact fabric, crease-proofing compound, fire-proofing finishes, wet-strength paper resins and resins for laminated paper containers. In brief the properties and characteristics of these materials are as follows:

FOAMED UREA RESIN. This material is a light-weight fluffy mass which has unique sound proofing and thermal insulating values. Quantitatively, its properties are:

Density—0.83 lb. per cu.ft.

Heat conductivity—0.23 b.t.u. per sq.ft. per hr. ped deg. F. per in.

Sound absorption (Box method):

Thickness (Inches)	Frequencies		
	256	512	1,024
¾	0.27	0.48	0.80
1	0.30	0.53	0.90
1½	0.41	0.75	0.80

DRY COATING SURFACE COMPOUND. This is a special modification of urea-formaldehyde cellulose compound which can be mixed with water and applied to surfaces by spray methods, then subsequently pressed to a hard impervious surface by pressure and heat. This material is generally applicable to hard materials, such as laminated phenolics, but requires control of the core material Obviously, this process is limited to smooth flat sheets.

LAMINATING RESINS. Urea laminating resins have been available for some time. Thin, flexible sheets using cloth or paper can be produced. Other resins are now available for the manufacture of laminated canvas for the production of high impact resisting molded forms. These materials are especially adapted to cold pressing or hot pressing using autoclave methods.

CREASE-PROOFING and wet-strength paper resins are used widely in the textile and paper trade but the present shortage of resin raw materials is seriously limiting their use. Undoubtedly when the present condition improves, this field will become more widely developed. These resins add so materially to the quality of the finished product that there will be an increasing demand for their use.

Table V—Specifications of Typical Urea Coating Resins

Non-volatiles	50–60%
Solvent (butanol)	30–20%
Thinner (xylene)	20%
Viscosity (Gardner-Holdt)	Wide range N–Z_2
Acid number	3.5 to 10
Water	0.1–4.5%
Compatibility (parts by volume)	
Xylene	Complete to 30–1
High solvency naphtha	5.6–1 to 21–1
Mineral spirits	3–1
Weight, lb. per gal.	8.4
Color	Water-white

Table IV—Types and Properties of Urea Adhesives

Adhesive	Form Supplied	Hot or Cold Press	Preparation for Use	Life of Mixture, 70 deg. F.	Spread, lb. per 1,000 sq. ft. Dry Basis	Assembly Time	Pressing Time at 70 deg. F.	Pressing Pressure Lb. per sq. in.	Pretreatment of Veneers	Principal Uses	Notes
Cold Setting	2 parts, pwdr. and hardener	Cold	Mix Cold	5 hr.	30–45	15 min.	6–12 hr.	100–300	none	Plywood joints, heavy cross sections	May be extended with flour or blood albumin.
Cold Setting	Ready-mixed	Cold	Mix Cold	5 hr.	30–45	15 min.	6–12 hr.	100–300	none	Household uses, furniture	May be extended with flour or blood albumin.
Hot Setting	2 parts, pwdr. and hardener	Hot	Mix Cold	1 day	25–40	48 hr.	Varies with temperature and thickness of veneer		none	Plywood, furniture, joints	May be extended with flour and albumin.
Modified	2 parts, pwdr. and hardener	Hot	Mix Cold	Several hours	15–30	Up to several days	Varies with temperature and thickness of veneer		none	Especially designed for formed plywood	

Materials Section

MICA AND ITS CONSERVATION

Mica, a highly important electrical insulation, is affected by the war because the imported material is cheaper and better. Development of domestic production, utilization of lower grades, and new designs for other materials are conserving present supplies.

MICA, 90 percent of which is used as electrical insulating material, owes its top rating in this field to its dielectric strength. This quality of mica is both initially high and well maintained at temperatures far beyond those ordinarily encountered in electrical apparatus.

RESISTANCE TO COMPRESSIBILITY, imperviousness, toughness, availability in thin sheets, the inability of water and oil to affect it, and its relatively low cost are also important. Its transparency is not important in insulation, but of course is well known and valued in minor applications of some grades.

MICA INSULATION is used in commutators for motors and generators, in high voltage armature coils, transformers, radio condensers, radio tubes, airplane spark plugs, control equipment and various forms of heating apparatus.

NO SUBSTITUTES for the best qualities of mica for insulation have yet been found which would permit of construction of many types of electrical apparatus in their present forms. Mica block and splittings suitable for the most important applications have always been imported, chiefly muscovite from India but also, in much smaller volume, phlogopite from Madagascar and Canada. The only reason for superiority of imported mica over domestic mica is its more careful preparation and better grading. The U. S. Bureau of Mines reported in 1935: "Comparable grades of mica, irrespective of source, are virtually identical as to dielectric strength and power factor."

By far the bulk of mica used in the U. S. is classed as "scrap," which is the raw material for making both wet- and dry-ground mica. Such mica is not "strategic" because ample supplies could be produced domestically at relatively short notice and because many of its uses are not essential to war needs. High grades of domestic mica are insufficient in quantity and are produced at greater cost.

Table I—Physical Properties of Mica

Thermal conductivity—Pure mica	0.0036
Paper mica	0.0016
Micanite (19 percent shellac)	0.0010
(11 percent shellac)	0.0012
Dielectric strength—Amber sheet 2 to 3 mils thick	2,000 volts per mil
White, ruby, or soft green 2 to 3 mils thick	3,000 to 4,000 volts per mil
Dielectric constant	2.5 to 5.9
Power factor	0.001 to 8.4
Specific inductive capacity	5.5 to 7.5
Density	2.7 to 3.1
Specific heat	0.206 to 0.208
Chemical analysis—Mica is a double silicate of alumina or magnesia, and potash or soda, combined with varying proportions of potash, soda, and other impurities.	

LOW-GRADE MICA. Relatively low qualities of mica block and splittings can be used for some purposes where higher qualities have been used before. Its use encourages domestic mica mining operations since a large part of the material produced is of such quality or is a by-product from the highest quality primarily sought. No restrictions in its use, therefore, are anticipated.

MOLDED MICA. The most important electrical insulation depending upon ground mica, which is usually made from scrap, is a molded material

bonded with lead borate and used extensively in high-frequency apparatus because of its low power factor, high mechanical strength, heat resistance and imperviousness. This material has better electrical characteristics than porcelain, and is stronger except under compression. It is not as refractory as porcelain or mica, but is superior in this respect to ordinary molded compounds. It has high chemical and dimensional stability and a low coefficient of thermal expansion.

Ground or powdered mica is used considerably in paints, roofing compounds, Christmas tree "snow," wallpaper and electrical insulation. It is also excellent for thermal and sound insulation.

BUILT-UP MICA. Production of built-up mica is dependent upon supplies of splittings. Its principal use is for commutator segments and other insulation for electric motors and generators. Shellac was used exclusively for bonding up to about 1925. Since then alkyd resins have been employed extensively and could successfully still further replace shellac, which comes only from India, in proved applications.

For rigid mica in commutator construction, shellac is used to a greater extent than alkyd resins, largely for economic reasons, but for flexible mica one large concern uses alkyd resin bonds exclusively. Shellac has been preferred in built-up mica for high voltage machines because of apparent greater stability under heat and pressure, and for cold-molded cones or V-rings for its faster setting up or hardening without application of heat during the molding operation. A modified alkyd resin bond was developed recently which will meet these and other special conditions. This is now on trial for the mica segments of commutators for railway motors. Experience of one large corporation indicates that alkyd resin cementing or bonding varnishes can be used to replace shellac entirely in all built-up mica, both rigid and flexible.

Some of the raw materials used for alkyd and modified alkyd bond, such as phthalic anhydride, glycerine and vinyl acetate, may not always be obtainable during war so that choice between shellac and synthetic bond may depend upon relative availability.

Built-up mica is available in many grades determined both by mica quality and size, and bonding material. One large manufacturer supplies 18 by 36 in. plate in most grades and a few grades 36 by 36 in. Thicknesses range from 0.005 to $\frac{1}{8}$ in. Combinations of mica with paper, cellophane, fish paper, press-board, and other materials are produced, as well as built-up mica tapes, tubing, segments of standard design, and V-rings.

Table II—Commonly Used Canadian Micas for Electrical Insulation

1. Milky amber	1. Soft, less heat-resistant than 3-4-5; used in splitting form for commutator segment mica
2. Approaching Milky Amber	
3. Medium Amber	Slightly harder than 1 and 2, more heat resistant; used principally for heater plate. Can also be used for segment plate.
4. Dark Amber	
5. Diamond (1) Amber	Exceptionally high grade of amber mica; considerably more heat resistant than 1-2-3-4. Limited quantity.

The properties of amber mica which give it preference over muscovite for some applications are higher heat resistance and greater softness. Muscovite mica will dehydrate or lose its water of crystallization between 1,020 and 1,110 deg. F. whereas temperatures between 1,290 and 1,830 deg. F. are required for dehydration of various amber micas.

Machining Built-up Mica

1. Punching is done with a die as with metal except that the stripper is a rubber ring fitted snugly around the punch and extending $\frac{1}{16}$ in. below the cutting edge. Die walls must be straight and smooth for at least $\frac{1}{8}$ in. from cutting edge. Close fitting of punch and die is essential.

2. Sawing is best accomplished with a band saw $\frac{3}{32}$ in. thick by $\frac{1}{2}$ in. wide, 8 points per inch, running at 5,000 ft. per min. Teeth should be set to cut slot $\frac{3}{64}$ in. wide. Several thicknesses, fastened together, should be sawed at one time.

3. Turning. In the lathe best results are obtained by using a sharp pointed high-speed steel tool with clearance angle of not less than 30 deg. and rake angle on top not less than 7 deg.

4. Drilling is done with regular high-speed twist drills running at a peripheral speed of 130 to 145 ft. per min. Drill point is ground at an included angle of 108 deg., same as for metal, but the hook on the lip is ground off, same as for drilling soft brass. Stacks backed with wood, fibre, or other material prevents flaking or excessive burrs. Tightly clamped steel jigs may be used also.

CLASS "B" INSULATION. For temperatures up to 257 deg. F., mica has been by far the most satisfactory basic material. It is required particularly for commutators of motors and generators, coils and high voltage rotating apparatus as well as radio tubes, condensers, and spark plugs. For these purposes India and Brazilian block and India and Madagascar splittings are decidedly superior and constitute the only satisfactory source of supply.

Of the two types of mica, muscovite or white India mica and phlogopite or amber from Madagascar, the former is more difficult to cut or mill in the built-up form commonly used in commutators and also more difficult to smooth off the surface by a sanding or grinding operation. Phlogopite is generally preferred for commutators because it wears down as fast as the copper.

As yet no suggested substitute for mica has proven acceptable. Substitutes are usually low in dielectric value, imperviousness, transverse strength, and water resistance in comparison with mica. Very thin films such as those made from Bentonite, a clay-like mineral, have been developed recently, but are not commercial substitutes.

Among the other inorganic materials available in sheet form, the most promising for partial replacement of mica are asbestos and fiber glass. In the usual woven or felted forms, both require filling of pores to secure imperviousness, but it is possible that clear solid glass may be secured thin enough to be of interest. It is also possible that an inorganic filler under investigation by one large company may become of practical value for filling porous Class "B" insulation.

Initial tests by some companies indicate the feasibility of using thin sheets of felted asbestos (a) on the cushion side of built-up mica to serve as a sanding surface; (b) for a backing on commutator shells; (c) in mica tubes in place of some of the mica; (d) for collars between decks of field coils and (e) in composite flexible mica, perhaps in conjunction with cellulose acetate. One large user of mica expects to reduce mica consumption about 6 percent by these substitutions.

CLASS "A" INSULATION. Mica is used to some extent where not technically required, as for slot insulation in DC armatures. It is probable that cellulose acetate, combined with other materials, can be used successfully.

Elimination of mica from transform-

ers and induction regulators has saved mica and reduced cost while providing an improved insulation. Very dense papers, such as pressboard, when thoroughly dried and filled with oil, are much better insulators. Substitution in transformer tanks was made possible by designing tanks to be water tight. Such elimination of mica was accomplished during the past five or six years. With regulators, the change was more recent and was accomplished by the same procedure.

Leading Applications

SPARK PLUGS. Airplane spark plugs contain so-called "cigarette" mica, a 0.030-in. wrapping surrounds the central electrode, which must be of highest grade mica. Domestic mica of suitable quality has lessened the difficulties of procuring washers for spark plugs except nose washers which are made of small block or punched phlogopite. The situation has been partly relieved by expansion of production in Canada.

Plugs having top chambers lined with mica of "cigarette" quality have been replaced by one manufacturer by heat-resisting glass tubes separated from the metal by an outer ring of sheet asbestos .

Mica may be dispensed with altogether in spark plugs as the result of development of improved ceramic cores by several manufacturers. Most of these appear to be made of high-alumina mixtures. Difficulties with ceramic plugs are largely of a design nature and due to the trouble of making metal and ceramic material compatible. Failure of a ceramic plug, however, may have more serious effects than failure of mica plugs. Engine manufacturers must, therefore, be extremely cautious in adopting ceramic plugs.

Substitution of ceramic spark plugs for mica plugs is necessary from the standpoint of improved spark plug reliability and engine performance, according to one manufacturer whose experimental work indicates that complete substitution of mica plugs will take place although it will take time for accomplishment.

CONDENSERS. Condenser mica is muscovite having special properties that make it more valuable than ordinary mica. Mica condensers are used principally in radio equipment and in magneto ignition systems for airplanes and tanks. Paper or other types of condensers can be used for most industrial service. For radio transmitter and high tension magneto condensers, clear mica was formerly specified, then slightly stained, and now fair-stained quality is generally used.

For radio receiver condensers and low-tension magneto condensers, good-stained mica is generally acceptable and actual requirements of sizes larger than No. 6 are relatively small. Selected Brazilian mica has been accepted recently and tests on domestic mica indicate that it also can be used. Bengal ruby mica was used almost exclusively until recently. No satisfactory substitute for mica in condensers for leading strategic uses is now indicated.

RADIO TUBES. Most of the mica used for bridges, spacers and other supports in radio tubes is good-stained India mica, No. 6. However, both South American and domestic mica have proved suitable for these uses and no difficulty is anticipated in obtaining supplies. If shortages should develop, it is probable that the situation could be relieved by reducing the quantities of good-stained or even stained mica used in certain household appliances.

Still another backlog is the possible substitution of porcelain and talc products, thus releasing mica for condensers.

COMMUTATOR WITHOUT MICA. Commutators of small motors used for refrigerators, vacuum cleaners, fans, etc., may be made entirely without mica by a construction covered by U.S. Patent No. 2,207,594. In this construction, instead of copper segments preformed to the exact shape and size required, a single copper strip is punched with notches or indentations along both edges.

This copper strip is then formed into the proper cylindrical shape over a preformed insulating sleeve which may be of a suitable sheet fiber. The prongs of the outer copper sheet are then firmly clamped over the inner insulating member and the metal mounting or supporting sleeve is molded into place by a suitable molding material, preferably of the synthetic resin type.

After the molding operation, which forms the supporting sleeve, the outer surface is machined to size and the copper segments formed by cutting through the copper strip from side to side at points indicated by the spaced notches of the original punched copper strip. One manufacturer is now producing 5,000 commutators weekly by this method. Both mica segments between commutator bars and mica cones or V-rings for insulating the backs of assembled bars are eliminated.

In another construction covered by U.S. Patent No. 2,141,307, the mica segments of commutators are replaced by mechanically dehydrated pressboard or cellulosic sheet material. The commutator construction is completed with either a mica V-ring or molded material without mica for internal insulation.

Many molded type commutators have been made by assembling the copper bars and mica segments and then molding the inner shell or support for this assembly, thus eliminating mica cones or V-rings. This method probably could be used for many small commutators up to about 7 in. dia. The method has been restricted for economic reasons and since phenolic resin compounds have been used commonly, a choice between them and mica might depend upon relative availability.

TOASTERS. The toaster is by far the largest user of mica in the appliance field. Mica can be practically eliminated from toasters, flat irons, waffle irons, coffee percolators, roasters, etc., by design changes to use refractory ceramic supports for heating elements although past experience shows them to be not quite as satisfactory as mica. About 50 percent of flatirons now employ an embedded unit of one type or another with no substantial amount of mica used for insulation.

Mica washers might be replaced by ceramic washers if proper design changes were made. Mica might be discontinued for fuse plug windows and rheostat washers if necessary.

Available Bonded Mica Combinations

PAPER: (1) Layers of mica splittings cemented together with flexible insulating compound and faced on both sides with a special tissue. (2) Layers of mica splittings faced on one side with thin shellac treated paper. Not flexible at room temperatures. Must be heated when used as a wrapper.

CELLOPHANE: Layers of mica splittings cemented together with flexible insulating compound and faced on both sides with moisture-proof cellophane 0.001 in. thick.

FISH PAPER: Layers of mica bonded with flexible insulating cement faced on one side with a special tissue and on the other with fish paper. Makes tough, high quality insulating wrapper.

PRESSBOARD: Layers of mica splittings pasted together with flexible cement, faced on one side with a special tissue paper and on the other with pressboard. Used where mechanical strength is important.

CLOTH: Layers of mica splittings faced on one side with a special tissue and on the other with cotton cloth, using a flexible cement.

CARBON-MOLYBDENUM STEELS

Steels in a wide range of carbon content are improved in physical properties by small additions of molybdenum. Since there are no standard S.A.E. analysis ranges for carbon-molybdenum steels, they are usually grouped into three carbon range categories. These are Low Carbon, Medium Carbon, and High Carbon. While each group has certain qualities which are more or less characteristic of the group, there are some properties which are possessed by all the carbon-molybdenum steels, such as suitability for forging, rolling, welding and machining operations. Also these steels respond uniformly to heat-treatment and are free from temper brittleness. The outstanding field for carbon-molybdenum steels is in the use of the material for parts that are subjected in service to elevated temperatures, where corrosion resistance is not an important factor. Data, tables and illustrations for this article are by courtesy of Climax Molybdenum Company.

Table 1—Properties of Carbon-Molybdenum Steels

	Low-Carbon Steels	Medium-Carbon Steels	High-Carbon Steels
Carbon range, percent	0.10–0.25	0.25–0.40	0.40 and more
Condition	As rolled	As rolled	Heat-treated, quenched and drawn
Tensile strength, lb. per sq. in.	70,000–80,000	80,000–100,000	160,000
Ratio of yield to tensile strength, percent	60–70 85 (when normalized and drawn)	60	85
Comments	Average hardness (0.15 to 0.20 C) is about 160 Brinell. Ductility is improved by normalizing and drawing. Readily weldable.	Ductility is slightly lower than that of the steels of the low carbon group. Amenable to heat-treatment. Readily weldable.	Ductility better than that of carbon steel. Hardness can be increased to a point where wear resistance becomes an important economic factor.

EFFECT OF MOLYBDENUM ON PHYSICAL PROPERTIES

Tensile Strength. Molybdenum improves the elastic properties of carbon steel. Molybdenum reduces the influence of "notch effects," and raises the fatigue strength of the steel. The ratio of tensile strength to yield strength ranges from 80 to 90 percent for most of the molybdenum steels in the heat-treated condition.

Hardness. By slowing down the transformation rate molybdenum promotes the uniformity and increases the depth of hardening. This property is an advantage when designing parts having heavy sections in which deep hardening is an important factor. Fig. 1 shows hardness readings across quenched 1⅝-in. rounds for three 0.35 percent carbon steels with various molybdenum contents.

Impact Strength. Since the tempering temperatures required to produce similar degrees of hardness are higher for the carbon-molybdenum steels than for plain carbon steels, there results a more complete relief from internal strains caused by the quenching operation with consequent greater impact strength. Molybdenum also, when present in adequate amounts, eliminates temper brittleness in steel.

Creep Strength. Research has revealed that molybdenum produces a marked increase in the lowest temperature of recrystallization after strain hardening. There can be little doubt that this effect is primarily responsible for the improved resistance to creep of molybdenum steels as compared with carbon steels.

Elevated Temperature Properties. The structural stability characteristic of molybdenum steels promotes the retention of hardness and strength at relatively higher temperatures than do similar compositions not stabilized by the presence of molybdenum, and also contributes to creep strength.

Table II—Physical Properties of Low Carbon, Carbon-Molybdenum Steel

Properties given are for " as rolled " plates

Plate Thickness, Inches	Analysis, percent				Tensile Strength, lb. per sq. in.	Yield Point, lb. per sq. in.	Elongation, percent in 8 in.
	C	Mn	Si	Mo			
1/2	0.16	0.76	0.17	0.44	82,450	50,000	24.0
5/8	0.17	0.75	0.18	0.41	80,900	45,900	26.0
11/16	0.17	0.75	0.18	0.41	82,200	43,800	28.0
3/4	0.15	0.81	0.18	0.47	76,700	47,360	25.7
7/8	0.15	0.80	0.19	0.44	74,300	45,820	27.6
15/16	0.14	0.84	0.19	0.48	75,810	47,030	25.7
1	0.16	0.76	0.17	0.44	76,170	46,410	25.2
1 1/4	0.15	0.78	0.17	0.48	74,320	44,960	24.4
1 3/8	0.17	0.86	0.21	0.47	76,600	42,600	27.8
1 1/2	0.18	0.73	0.19	0.44	74,515	45,350	23.6
1 5/8	0.14	0.84	0.19	0.48	74,175	44,325	25.7
3 1/8	0.13	0.90	0.21	0.48	71,600	41,800	26.5

INFLUENCE OF MOLYBDENUM ON HEAT-TREATMENT

1. Upper critical point is slightly raised on heating and lowered on cooling.

2. Commercial safe quenching and normalizing temperature limits are widened. Molybdenum carbides go into solution relatively slowly, hence the required times at quenching and normalizing temperatures are somewhat increased.

3. All transformation changes are retarded.

4. Higher tempering temperatures are required to produce equivalent hardness. The structural stability of molybdenum steels permits the use of high tempering temperatures without undesirable loss of strength and hardness. As a result of the high tempering temperature employed quenching strains, which would otherwise contribute to poor impact strength, may be more completely removed than are the quenching strains developed in carbon or alloy steels where lower tempering temperatures must be used.

5. Temper brittleness is practically eliminated. Most molybdenum steels retain their impact strength on slow cooling and do not require quenching after tempering. Molybdenum steels soften less at the relatively high tempering temperatures required to relieve casting, forging and quenching strains than do steels not containing molybdenum. Also, high impact strength at high hardness and tensile strength result from the high tempering temperatures. In Fig. 2 is shown the degree of softening with increasing tempering temperature of a quenched 0.35 percent carbon steel with and without molybdenum.

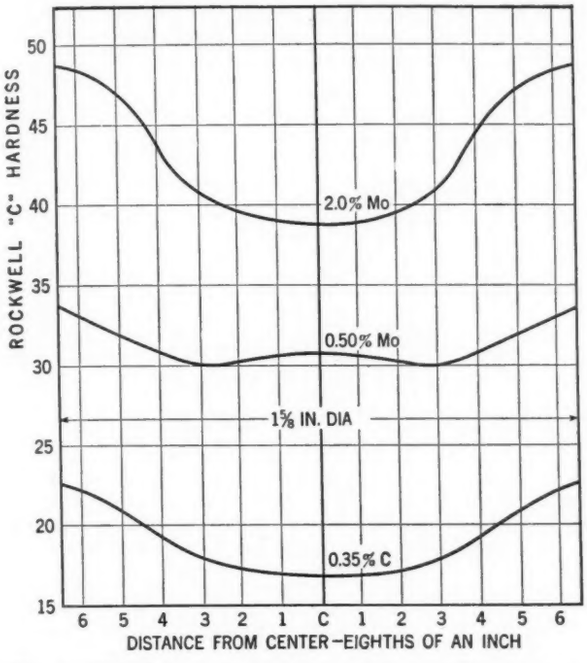


Fig. 1—Distribution of hardness after quenching across three round bars of 0.35 percent carbon steels with different molybdenum content

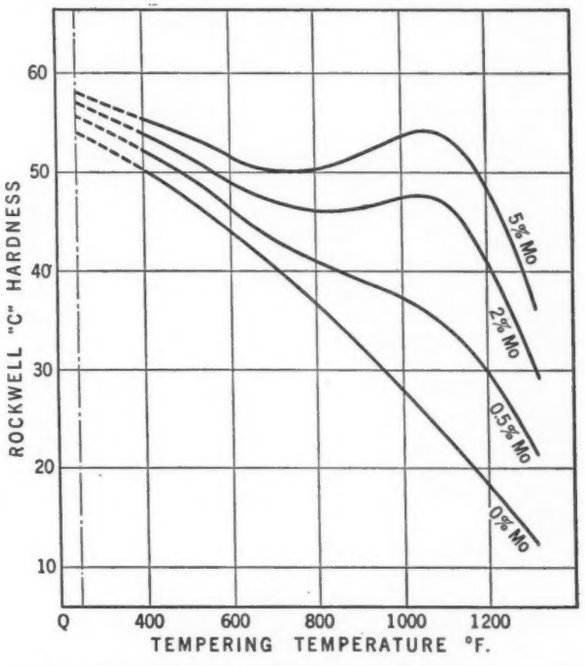


Fig. 2—Effect of tempering temperature on degree of softening of quenched 0.35 percent carbon steels with varying molybdenum content

EFFECT OF MOLYBDENUM ON FABRICATION QUALITIES

FORGING. Molybdenum tends to inhibit undesirable grain growth of steel during the soaking operation before forging. Molybdenum steels are free scaling, therefore, forged parts have smooth surfaces; there also results increased die and tool life, and decreased pickling costs.

CASE HARDENING. Molybdenum improves the properties of the case of steels developed by either the carburizing or nitriding process, in both the penetration of the hardening medium is accelerated. The distortion of case-hardening steels containing molybdenum is small and uniform.

Molybdenum carburizing steels are characterized by tough strong cores with hard cases well bonded to the core. Because the case retains its hardness at relatively high operating temperatures these steels are valuable for gears.

Molybdenum steels in the carbon range 0.35 to 0.45 percent are excellent flame hardening steels. Molybdenum increases hardenability. Since molybdenum inhibits grain growth over the transformation point, the steels react favorably to flame hardening. A loss of control of hardening temperature while case-hardening does not necessarily result in spoilage.

MACHINING. Molybdenum steels often machine more easily in the fully heat-treated condition than do similar alloy steels not containing molybdenum when heat-treated to hardness above 300 Brinell. In the softened condition, if properly heat-treated, molybdenum steels do not offer any difficulty in machining under ordinary shop conditions.

WELDING. Many molybdenum steels are readily welded by either gas or arc processes. Molybdenum retards grain growth above normal coarsening temperatures, thus reducing the undesirable effects of excessive grain growth which sometimes occur.

DEEP DRAWING BRASSES

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Revere Copper and Brass Incorporated

COMMON HIGH BRASS, a generic name for alloys of copper and zinc containing 64 to 67.50 percent copper, is frequently subdivided into two groups of higher and lower percentages of copper. The alloys having the higher percentage of copper are known as Deep Drawing or Spinning brass and those having the lower percentage of copper are known as Common High or Two and One brass.

Under normal conditions this group of brasses is used far in excess of all other brasses combined but is now second to cartridge brass. They possess excellent cold working properties in combination with corrosion-resisting properties only slightly inferior to 70-30 brass.

Complete mechanical properties of cold worked and annealed Deep Drawing brass are given by the accompanying charts. In the cold working as well as in the annealing series for Deep Drawing brass strip, properties are given for two different ready-to-finish grain sizes, 0.015 and 0.100 mm., which represent limits commonly encountered in commercial annealing. Terminology is the same as in previous articles on other brasses.

These charts show that mechanical properties are markedly influenced by ready-to-finish grain size, especially the cold worked series shown in Figs. 1 to 4. A different range of properties is established, of course, for each number of hardness and this range is recognized in commercial specifications.

The influence of ready-to-finish grain size on material that has been cold worked 6 numbers and then annealed is less marked, as is evident in Figs. 6 to 11, but nevertheless is as important. Material having the smaller ready-to-finish grain size of 0.100 mm. has consistently lower mechanical properties. Grain growth is more rapid in the brass of larger ready-to-finish grain size.

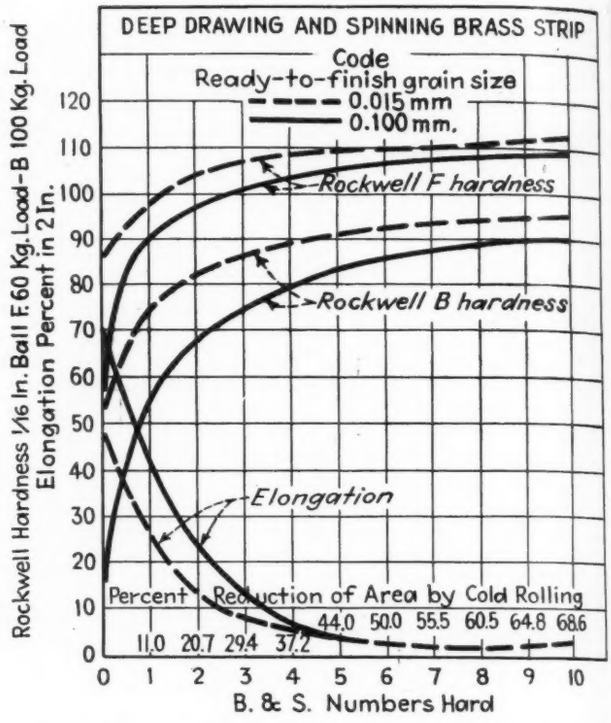

DEEP DRAWING AND SPINNING BRASS STRIP
Code
Ready-to-finish grain size
0.015 mm
0.100 mm.
Rockwell F hardness
Rockwell B hardness
Elongation
Rockwell Hardness 1/16 In. Ball F 60 Kg. Load-B 100 Kg. Load
Elongation Percent in 2 In.
Percent Reduction of Area by Cold Rolling
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
B. & S. Numbers Hard

Fig. 1—Effect of cold working on hardness and elongation of Deep Drawing brass strip. Variation in ready-to-finish grain size is not as effective on elongation as upon hardness, the spread between dotted and solid line curves indicates

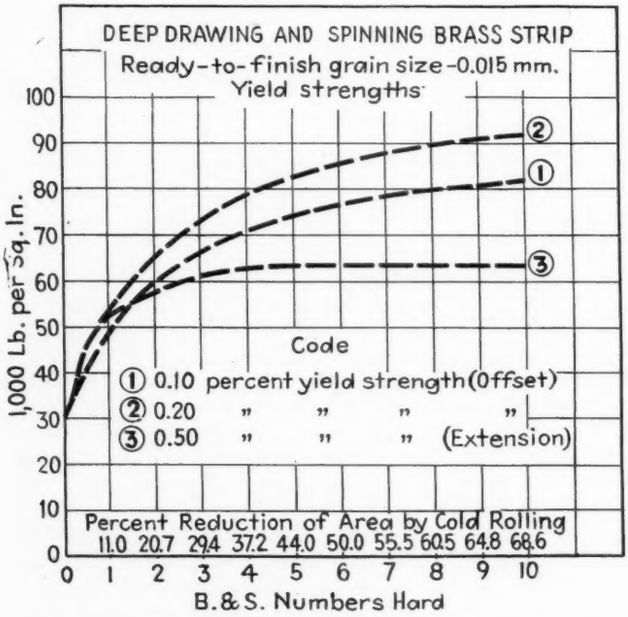

DEEP DRAWING AND SPINNING BRASS STRIP
Ready-to-finish grain size-0.015 mm.
Yield strengths
1,000 Lb. per Sq. In.
Code
① 0.10 percent yield strength (Offset)
② 0.20 " " " "
③ 0.50 " " " (Extension)
Percent Reduction of Area by Cold Rolling
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
B. & S. Numbers Hard

Fig. 2—Effect of cold work on yield strength when ready-to-finish grain size is 0.015 mm. Fig. 3 shows the difference in effect when ready-to-finish grain size is 0.100 mm.

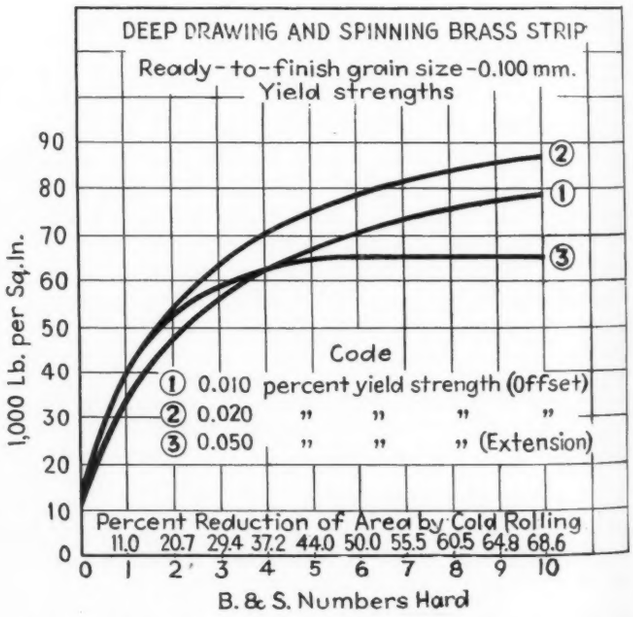

DEEP DRAWING AND SPINNING BRASS STRIP
Ready-to-finish grain size-0.100 mm.
Yield strengths
1,000 Lb. per Sq. In.
Code
① 0.010 percent yield strength (Offset)
② 0.020 " " " "
③ 0.050 " " " (Extension)
Percent Reduction of Area by Cold Rolling
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
B. & S. Numbers Hard

Fig. 3—Effect of cold work on yield strength when ready-to-finish grain size is 0.100 mm. Fig. 2 shows the difference in effect when ready-to-finish grain size is 0.015 mm.

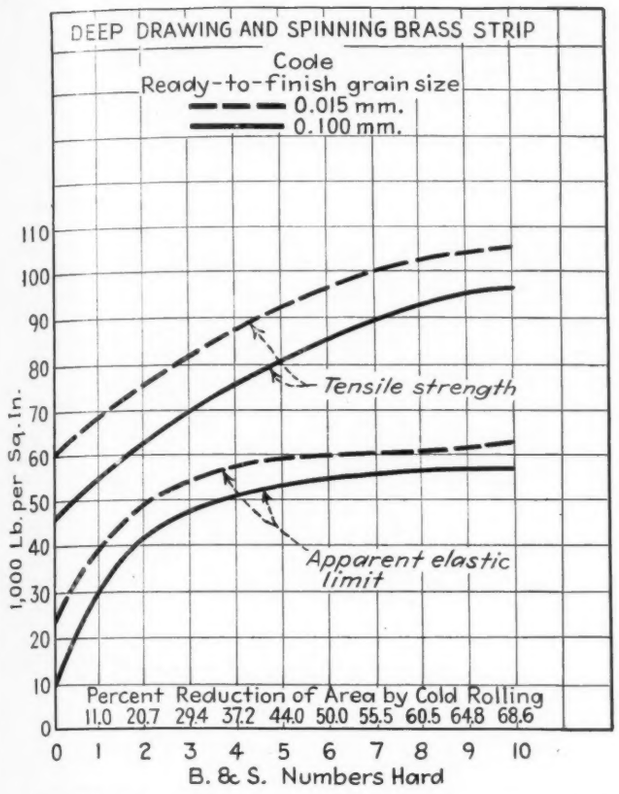

DEEP DRAWING AND SPINNING BRASS STRIP
Code
Ready-to-finish grain size
0.015 mm.
0.100 mm.
Tensile strength
Apparent elastic limit
1,000 Lb. per Sq. In.
Percent Reduction of Area by Cold Rolling
11.0 20.7 29.4 37.2 44.0 50.0 55.5 60.5 64.8 68.6
B. & S. Numbers Hard

Fig. 4—Effect of cold working on tensile strength and apparent elastic limit of brass strip. The space between the solid and dash lines shows the influence of ready-to-finish grain size on physical properties

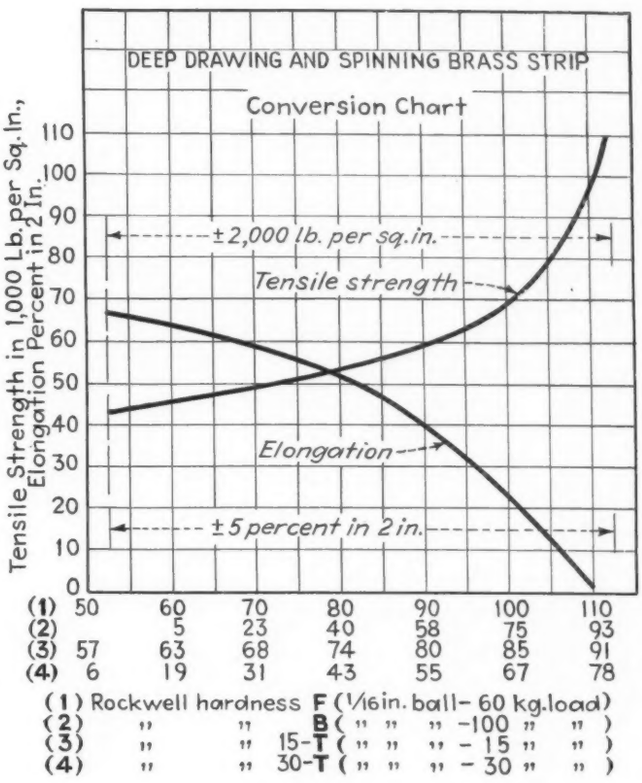

DEEP DRAWING AND SPINNING BRASS STRIP
Conversion Chart
Tensile Strength in 1,000 Lb. per Sq. In., Elongation Percent in 2 In.
±2,000 lb. per sq.in.
Tensile strength
Elongation
±5 percent in 2 in.
(1) 50 60 70 80 90 100 110
(2) 5 23 40 58 75 93
(3) 57 63 68 74 80 85 91
(4) 6 19 31 43 55 67 78
(1) Rockwell hardness F (1/16 in. ball - 60 kg. load)
(2) " " B (" " " -100 " ")
(3) " " 15-T (" " " - 15 " ")
(4) " " 30-T (" " " - 30 " ")

Fig. 5—Approximate tensile strength and percentage elongation of Deep Drawing brass strip can be determined when only the Rockwell hardness is known. Accuracy is within the given limits for thickness of 0.020 to 0.080 in.

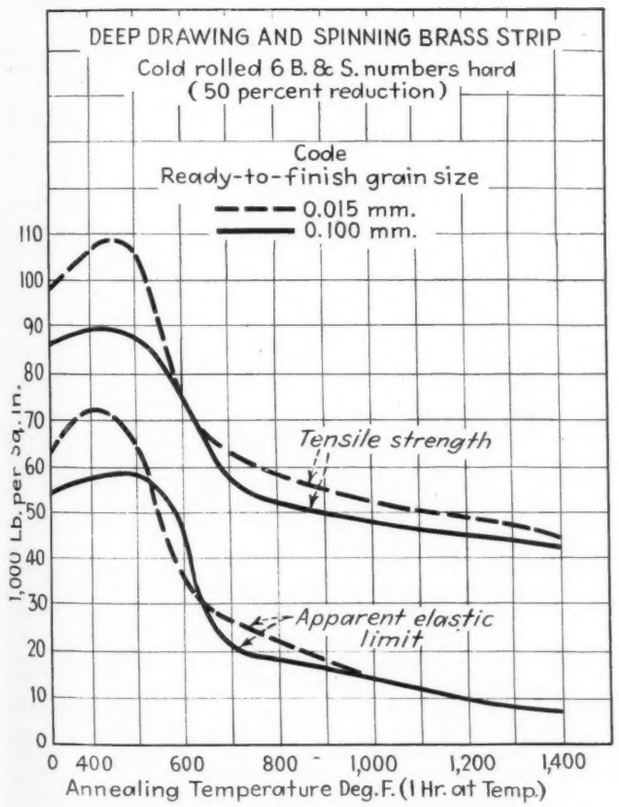


Fig. 6—Effect of annealing after cold rolling on tensile strength and apparent elastic limit of brass strip having two different ready-to-finish grain sizes

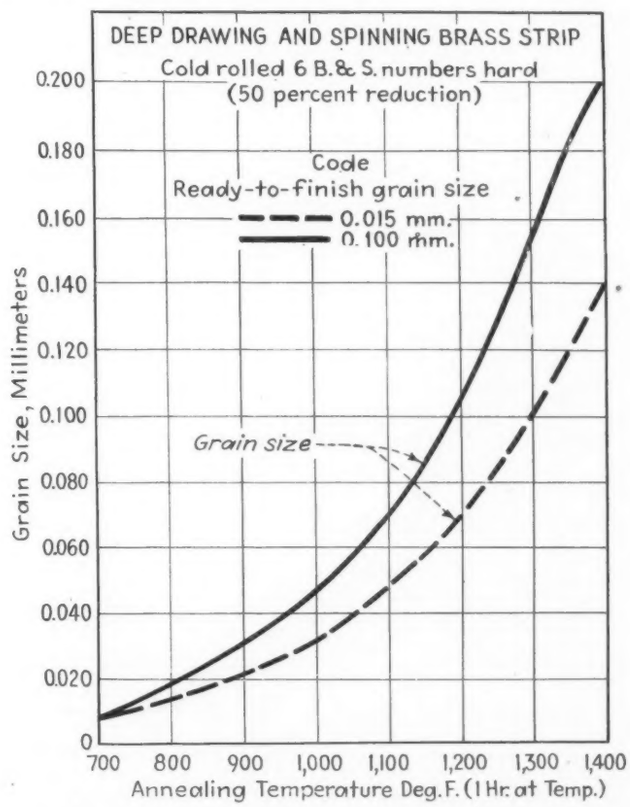


Fig. 7—Difference in final grain size as affected by annealing brass strip 6 numbers hard with ready-to-finish grain sizes of 0.015 and 0.100 mm.

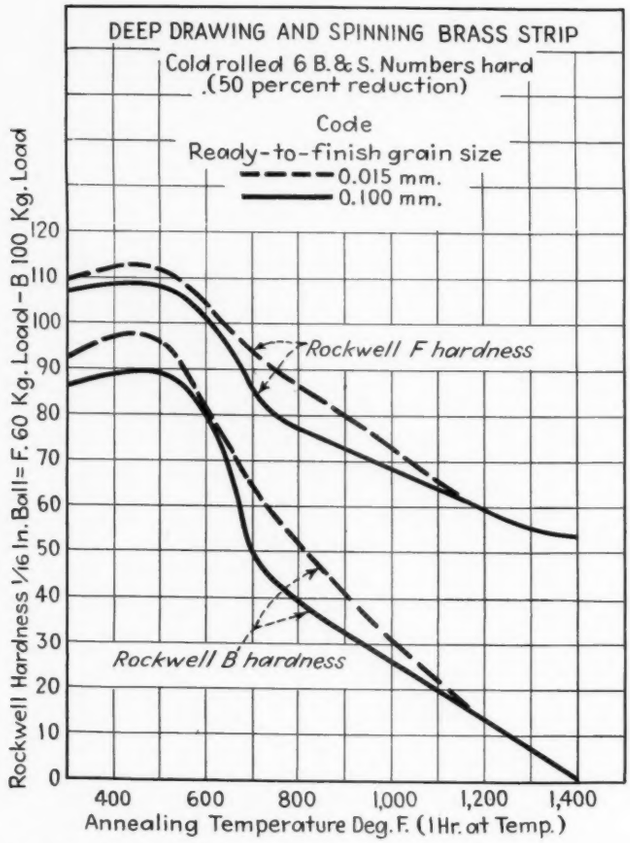

DEEP DRAWING AND SPINNING BRASS STRIP
Cold rolled 6 B. & S. Numbers hard
(50 percent reduction)
Code
Ready-to-finish grain size
0.015 mm.
0.100 mm.
Rockwell F hardness
Rockwell B hardness
Rockwell Hardness 1/16 In. Ball = F. 60 Kg. Load - B 100 Kg. Load
Annealing Temperature Deg. F. (1 Hr. at Temp.)

Fig. 8—Effect of annealing temperature on hardness of brass strip of two ready-to-finish grain sizes, previously cold worked to 6 numbers hard

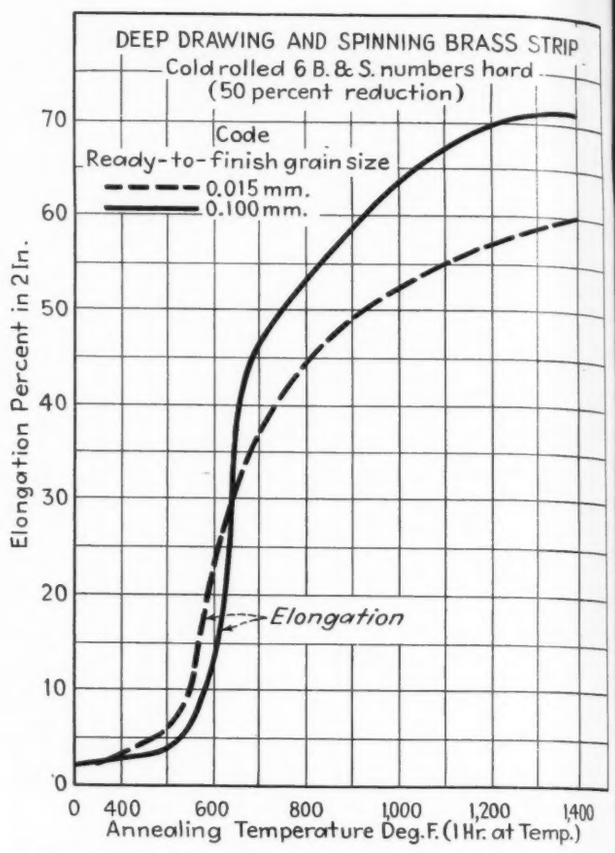


Fig. 9—Effect of annealing temperature on elongation of brass strip of two ready-to-finish grain sizes, previously cold worked to 6 numbers hard

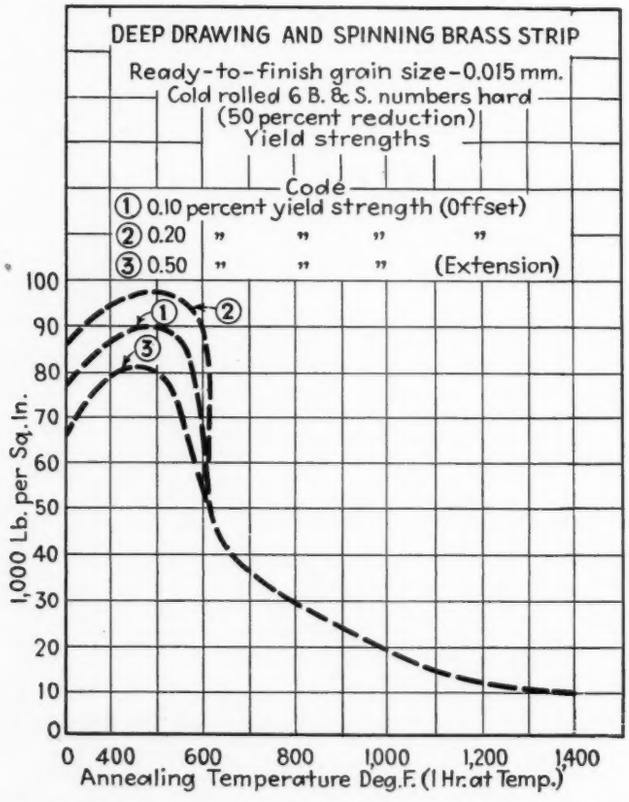

DEEP DRAWING AND SPINNING BRASS STRIP
Ready-to-finish grain size - 0.015 mm.
Cold rolled 6 B. & S. numbers hard
(50 percent reduction)
Yield strengths
Code
① 0.10 percent yield strength (Offset)
② 0.20 " " " "
③ 0.50 " " " (Extension)
1,000 Lb. per Sq. In.
Annealing Temperature Deg. F. (1 Hr. at Temp.)

Fig. 10—Effect of annealing on yield strength of brass strip after cold working to 6 numbers hard. Influence of ready-to-finish grain size can be compared in Figs. 10 and 11

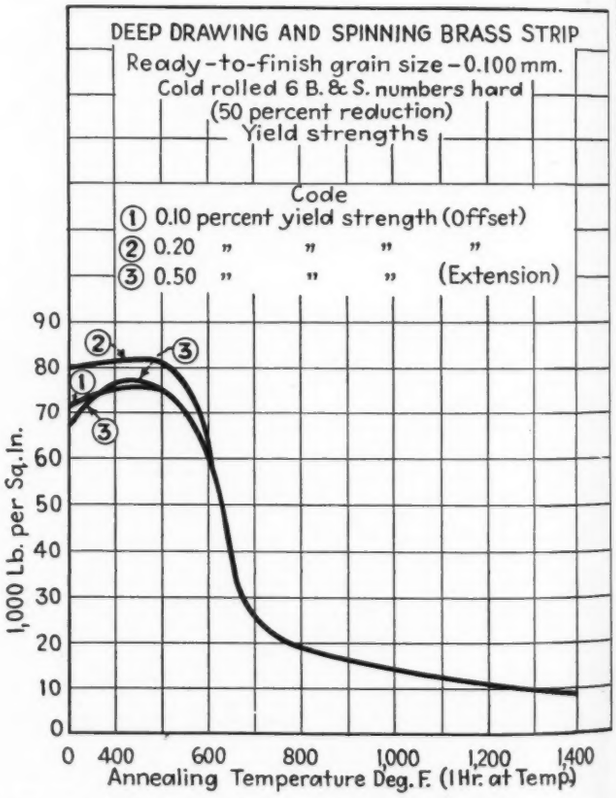

DEEP DRAWING AND SPINNING BRASS STRIP
Ready-to-finish grain size - 0.100 mm.
Cold rolled 6 B. & S. numbers hard
(50 percent reduction)
Yield strengths
Code
① 0.10 percent yield strength (Offset)
② 0.20 " " " "
③ 0.50 " " " (Extension)
1,000 Lb. per Sq. In.
Annealing Temperature Deg. F. (1 Hr. at Temp.)

Fig. 11—Effect of annealing on yield strength of brass strip after cold working to 6 numbers hard. Influence of ready-to-finish grain size can be compared in Figs. 10 and 11

CADMIUM APPLICATIONS

THE MAJOR USES of cadmium, for electroplating and babbitt bearings, are not indispensable. The uses in which cadmium are really vital are those in which it enters an alloy as a minor constituent. Such uses are in silver solders and "fusible alloys."

There is perhaps greater engineering justification for demanding cadmium-base babbitt for exacting bearing requirements than there is for demanding cadmium-plated steel for its more common uses, since zinc-plated steel is so nearly indistinguishable in corrosion resistance. Since there is not enough cadmium to go around in bearing applications, however, and other metals are required anyway, little is to be gained by trying to control distribution of cadmium to different uses as long as the small amount required for the non-substitutable uses remains available.

Cadmium plate affords the same sort of electrochemical protection to steel as does zinc, in either electroplated or hot-dipped coatings. Cadmium does not dull and become encrusted with carbonate quite as soon as zinc does, and therefore would be preferred to zinc at equal cost and availability. Actual protective value of the coating is little if any superior to that of an equal thickness of zinc coating, except under exposure to salt spray, and the advantages may be on the side of zinc, particularly in outdoor exposure in industrial atmospheres high in sulphur dioxide.

Even the initial good looks and decorative value of a fresh cadmium plate can now be approximated with modern "bright" zinc plating, though the zinc does not so well resist finger marking and development of white tarnish from oxidation when kept in storage.

Table I—Comparative Properties of Cadmium-Base Bearings In Connecting Rod Service

(Materials used as linings of steel-backed bearings)

	Seizure Resistance	Oiliness	Corosion Resistance	Strength	Melting Point	Embeddability	Ease of Bonding
Babbitt	3	2	1	4	3	1	1
Cadmium Base	3	3	3	3	2	2	2
Copper-Lead	2	1	2	2	1	3	3
Pure Silver	1	4	1	1	1	3	4
Silver-Lead	1	2	1	1	1	3	5

Table II—Tensile Properties of 95 Percent Cadmium 5 Percent Silver Alloys

Temperature Deg. F.	Ultimate Tensile Strength Lb. per sq. in.	Elongation in 2 in. Percent	Reduction of Area Percent
Room	16,400	31.3	81.0
300	4,400	93.7	91.0
425	2,600	93.7	68.0
500	1,700	21.9	11.0

Table III—Physical Properties of Cadmium

Tensile strength	13,660 lb. per sq. in.
Elongation	44 percent in 3 in.
Melting temperature	610 deg. F.
Hardness, Brinell	29 (harder than tin)
Specific heat	0.0567
Color	Silvery white with faint blue tinge and bright lustre which fades on exposure to atmosphere
Can be cut with a knife, is flexible, ductile, and malleable	
Thermal conductivity	0.222 at 65 deg. F.
Coefficient of thermal expansion	28.8 x 10–6

Cadmium-Base Bearings

The cadmium-base babbitt-type bearing metals are more important. Cadmium has a higher melting point than tin, and the cadmium-base babbitts retain their strength at higher temperatures than do the tin-base babbitts. This is of value for automobile engines that run too hot for tin-base babbitt. However, since these bearings are somewhat more susceptible to corrosion, their use has been limited. Use of various lubricating oil inhibitors, adjustment in alloy composition, and of bearing surface treatments may entirely overcome this objection.

Alternate Bearing Materials

Copper-lead bearings, or those made from special lead alloys, can be made to serve instead of cadmium-base babbitt. It is also possible to electro-deposit a cadmium-silver alloy of good bearing properties, and a thin film of such an alloy upon a suitable backing could be made to serve where a thicker layer is now applied by ordinary babbitting methods.

The need for cadmium-base babbitt was decreased by recent developments in bearings with very thin linings of tin-base or lead-base babbitt on steel. The thin-lining, snap-in type of bearing is widely used in automobiles but not so widely in other types of service.

Solders

The principal industrial application of cadmium-silver alloys is in solders. Alloys high in cadmium, such as 82.5 percent Cd, 17.5 percent Zn, or 95 percent CD, 5 percent Ag, are useful solders, and up to about half of the tin in lead-tin solders could be replaced by cadmium. In wiping solder (normally 62 percent Pb, 38 percent Sn) an alloy of 68 percent Pb, 23 percent Sn, 9 percent Cd has satisfactory properties. However, the cadmium supply would not go far in substitution in a tin shortage and lead-silver solders are a more practical replacement for lead-tin solders. The use of wiping solder can be avoided by turning to lead-burning technique.

The principal advantage of cadmium silver solders over lead-tin solders is their considerably higher strength at all temperatures. They are used where temperatures are too high for standard silver brazing alloys. The strength of cadmium-silver solders is not as high as

in other silver brazing alloys but joints of 95 percent cadmium 5 percent silver have the same strength at 400 deg. F. as soft solders at room temperature.

Silver Solder

Silver soldering, or more correctly, brazing with a silver-containing alloy, gives the strongest joint that can be obtained short of welding. "Brazing" with silver solder may become important in aircraft construction since joining may be done at so low a temperature that the alloy steel tubing is not impaired. The silver solder for this purpose contains 50 percent silver, 15.5 percent copper, 16.5 percent zinc, and 18 percent cadmium. The cadmium is essential in producing the low melting point and high fluidity of the solder.

Fusible Alloys

Fusible alloys containing 10 percent cadmium are important in the bending of copper and aluminum tubing required in aircraft and other applications. These alloys, due to the presence of cadmium, can be melted by steam or in a hot water bath. Fixtures and assembly jigs used by the aviation industry are also assembled with fusible alloys. Such use of cadmium is relatively small since the alloy is used over and over but it has been at least doubled by defense requirements.

Storage Batteries

A use for cadmium not yet greatly developed in the U. S. is in a nickel-cadmium storage battery. It is reported that, because of their reliability and freedom from deterioration when not in use, they are used by the English and Russian forces in planes, tanks, and submarines, as well as in batteries for the fire control equipment on battleships and cruisers.

While the Edison cell is satisfactory now for such applications there is a possibility that cadmium batteries might fill expanded needs.

Increased Production

The price for any huge increase in cadmium would be prohibitive because cadmium occurs in commercial tonnages only as a minor constituent of zinc ores and is produced as a by-product. No workable deposits of cadmium ore, as such, are known. The amount available depends not only upon the quantity of cadmium in the zinc ores, but also upon the tonnage of high purity zinc that is made. About 1,900 tons of cadmium were used for plating in 1940, and 575 tons for bearings.

Finishing

The most common method of finishing is "bright dipping" in acid solutions. Mechanical finishing operations are used only to a small extent. Such a finish requires care to assure adhesion and to prevent blisters. Large parts are usually buffed or scratch brushed with light pressure. Small parts may be ball burnished. Sometimes cadmium plate is finished by lacquering or painting and this also requires special treatment for satisfactory adhesions.

Coloring

Coloring of cadmium plate is uncommon but a few formulas have been applied successfully. The colored films are produced by oxidizing agents that have good corrosion resistance. Such films may be gray or imitate other metals such as pewter, wrought iron, Swedish iron and silver.

Forming

Plated flat blanks can be formed to desired shapes because of the ductility of the coating. Cadmium plated surfaces are readily soldered.

Casting Characteristics

General casting characteristics of cadmium alloys are excellent. Small additions of silver improve casting quality by making the alloy less susceptible to oxidation at casting temperatures, improving fluidity, and increasing hardness.

Oxidation during melting is serious in some compositions. Addition of 0.05 percent magnesium is one way of overcoming this trouble but it is detrimental to "tinning" power and other properties. Overheating is to be avoided to prevent drossing. Presence of tin speeds drossing also.

Health Hazards

Cadmium should not be used on vessels or containers for food products nor on cooking utensils because it may be absorbed by the food and act as a poison. Poisoning may also occur in working with cadmium or its alloys as in welding, soldering, spraying of cadmium bearing paints and pigments, production of cadmium compounds, melting the metal and cadmium-plating processes.

Plating

Cadmium is easy to plate with conventional equipment, giving less trouble than most other metals. Plating is done faster and requires less equipment and floor space. Cadmium plating is practically all done on the rough or machined surface of a metal without polishing or buffing and the cadmium coating is generally used also without further polishing.

Cadmium covers malleable iron and zinc die castings easily, calling for relatively little care in removing grease and oxides. Good adhesion can be obtained on stainless steel and certain aluminum alloys.

While cadmium can be applied by spraying and hot dipping as well as by plating, the latter method is universal.

Major Problems

Black discoloration occurring during storage without air circulation was cured by pretreatment of the surface with chromic acid solution containing 20 oz. per gallon of water and 0.54 oz. of sulphuric acid per gallon. Small parts may be dipped.

White powder corrosion in closed systems with electric insulating materials was cured by using a phenol condensation lacquer.

Seizing

Cadmium coatings tend to prevent seizure of threads. Turnbuckles are, therefore, often plated with cadmium to secure this advantage as well as to protect against rusting. This property has also been utilized in the prevention of seizure of automobile pistons during the "run-in" period, though the use of tin for this purpose is more common. Chemically applied coatings that produce an oil-retaining surface are likewise employed for this purpose.

Since cadmium resists alkaline solutions and soap it is used considerably on washing machine parts, floor cleaning machinery, mops, clothes wringers, and lavatory fittings.

Low electric contact resistance makes cadmium more satisfactory than copper for electric contact surfaces since its resistance rise is less than copper after oxidation. It is also a good protection between brass and zinc parts when they are in contact.

Galvanic corrosion between Duraluminum and rivets is prevented by cadmium plating the rivets thus preventing reduction in strength and ductility of the sheets.

[The above data, except under the head of Plating, is abstracted largely from a recent report by H. W. Gillett for the Metals Conservation and Substitution Group of the Advisory Committee on Metals and Minerals, National Academy of Sciences.]

SILVER COATED STEEL

Use of silver as a coating to replace nickel and chromium and even as a substitute for tin linings of food cans is a practical possibility in view of many desirable properties and workability of silver coatings.

PHYSICAL PROPERTIES

OF ALL METALS, silver has the whitest color, highest electric and thermal conductivity, and highest optical reflectivity. Only gold exceeds it in ductility and malleability. The combination of plasticity and fairly high tensile strength is notable. Though tensile strength is satisfactory for ordinary structural use, it yields more readily than most metals to plastic flow under pressure. Deficiencies of silver are that it is a mechanically soft, weak metal easily scratched and abraded, and it tarnishes readily in urban and industrial atmospheres. Its germicidal properties may be of value in some applications.

Density—0.378 lb. per cu. in. at room temperature. Depends on mechanical state. Density of cold worked silver is slightly less.

Hardness—27.0 Brinell for slowly cooled and annealed silver.
24.4 Brinell for rapidly cooled material
32.0 Brinell is possible depending on degree of reduction

Young's Modulus—10,300,000 lb. per sq. in. (decreases with increase in temperature)

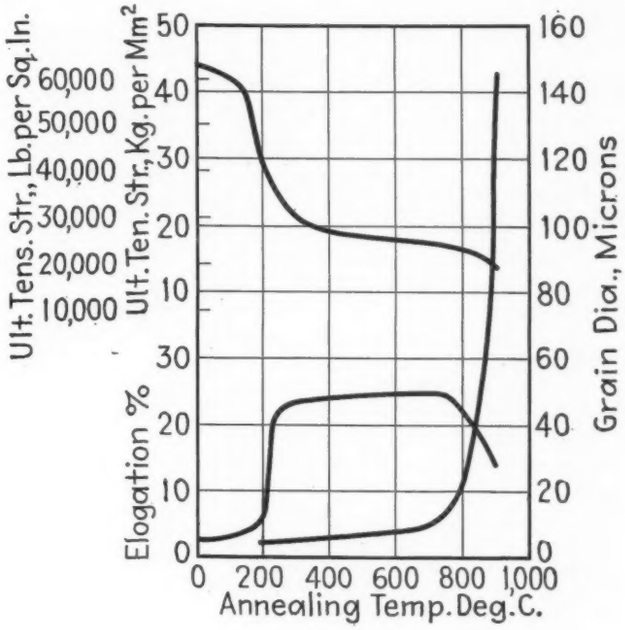
Freezing point—1,581 deg. F.

Thermal conductivity—1 cal. per sec. per deg. C. per sq. cm. per cm. thickness

Thermal expansion—1.910 x 10^{-5} per deg. C.

Specific heat—0.056 cal. per gram per deg. C. at 0–100 deg C.

Coefficient of friction against iron—0.3 (lowest of any combination tested)
High purity silver, backed by steel, makes bearing of excellent load-carrying ability. Extreme resistance to galling and scoring is reported in sliding contact with steel. From 3 to 5 percent of lead is said to further improve such bearings.



Ultimate tensile strength—22,500 lb. per sq. in. for fully annealed silver
This is close to copper and above gold. Sufficient cold rolling increases this figure to 54,000 lb. per sq. in.

Corrosion Resistance. Ability to resist corrosion is one of the most favorable properties of silver. No protective oxide film is formed as with aluminum, and silver is strongly resistant to atmospheric and ordinary oxidation. It is exceptionally resistant to corrosion by weak acids and most organic compounds, including those commonly met in food products.

Silver dissolves readily in nitric acid and hot sulphuric acid and is attached by strong halogen acids, including concentrated hydrochloric acid. Cyanide solution, sulphur and many of its compounds, and mercury and its compounds also attack silver. Silver is, however, often resistant to corrosion by agents under certain conditions and not under others. Chemicals that do not react with silver are listed in "Silver in Industry," edited by Lawrence Addicks and published in 1940 by Reinhold Publishing Company, and in *Chemical and Metallurgical Engineering*, Nov. 1938, p. 637.

Tarnish, which is silver sulphide, is formed by contact with traces of gaseous hydrogen sulphide in the air as well as by contact with egg yolk or rubber. No satisfactory method has been devised to prevent tarnish formation although certain alloys have higher resistance to tarnish than commercial silver. Lacquers are not permanent. Best method of tarnish removal is the electrolytic method, using salt or soda solution with aluminum or zinc, since no silver is removed. However, polish may be necessary to brighten the surface again. Most household polishes are somewhat abrasive but the amount of silver removed is usually minute.

Silver Coating Methods. Although electroplating is the best known method of applying silver coatings, other methods are in common use. Thickest coatings are generally applied by welding and, roughly in order from thick to thinnest coatings, the methods are spraying, cladding, hot dipping, electroplating, chemical reduction, vaporization from a hot filament in a vacuum, and cathode sputtering, which is an electrostatic process. Chemical reduction is used in silvering mirrors and reflectors, vaporization in sealed beam headlamps, and cathode sputtering in scientific instruments for the most part.

Silver Cladding. Silver-cladding has been confined chiefly to bonding fine silver to steel and copper although it has been applied to other metals such as nickel and brass. Silver thickness now available varies from ¼ in. down to 0.01 in. Sheets up to 25 in. width are produced. Cost is about $1.50 per pound for plate ⅛ in. thick or heavier, 10 percent silver clad steel.

Silver-clad materials are workable by various methods now applied to the base metals. Experience indicates bond will stand all types of cold rolling, drawing, spinning and other forming operations. When intermediate anneals are required, silver-clad steel must not be heated above 1,200 deg. F.

Electroplating Precautions. Embrittlement of steel may occur in plating baths. This may be serious if steel has

been work-hardened and has low initial ductility. Annealing of work-hardened steel prior to plating is recommended.

Production of pore-free deposits requires (a) selection of base metal of relatively smooth surface, free from pits, scale, scratches, and excessive amounts of non-metallic inclusions, and (b) scrupulous care in maintaining plate solutions free from suspended matter.

Castings are difficult to plate satisfactorily. Fittings assembled by brazing from wrought tubing and sheet, or else forgings, are preferred. In general, the thinner the coat and the less cost of preparation for plating, the better the surface finish must be.

Low-Temperature Bonding. Silver is superior to all metals except gold in low-temperature bonding. Properties which account for this are its chemical nobility, plasticity, and low temperature of recrystallization after work-hardening. Adsorbed oxygen or air is readily removed from the surface by simple preheating, and there is no danger of forming a hindering oxide film.

Low-temperature bonds may be made at 750 deg. F. Silver strips are rolled, receiving about 50 percent reduction of area. In tests of this method, surface conditions was not important. Steel may be silver plated this way also although the bond is not as good as silver to silver.

Bonding properties make silver adaptable to powder metallurgy technique and such use is reported to be increasing.

Forming. Deep-drawing steel of good commercial grade can be electroplated with silver upon a copper undercoat to form a silver coating 0.0001 in. thick. A 0.001-in. coating of silver over a suitable undercoat such as copper can be subjected to drastic forming and heating operations without damage to the coating. Surface of forming tools should be non-ferrous.

Minimum recommended thickness of copper undercoat is 0.001 in. For forming operations in which heating is involved, copper undercoat should be separated from silver deposit by a nickel deposit or nickel strike coating, for example from Wood's nickel bath, before depositing silver coat. When thick coating is required, a combination of 0.001 in. of silver on a nickel strike over 0.015 to 0.20 in. of copper adheres perfectly and withstands severe forming operations without developing porosity. The nickel layer prevents diffusion. Silver coatings sometimes blister and peel if exposed to relatively high temperature in an oxidizing atmosphere.

Deep-drawing steel may be electroplated with silver and subjected to extensive reduction by cold rolling, to annealing, and further cold rolled without separating or injuring the silver coat. This treatment is applicable to large sheets.

Spinning. Samples of bright-finish steel, plated with 0.001 in. of copper and 0.001 in. of silver have been spun into various hollow ware shapes without causing separation of silver.

Low Cost Containers. Possibility of manufacturing low-cost silver-lined containers such as drums, barrels, and cans has been demonstrated. Food or beer cans 2½ in. in dia. and 4½ in. high would carry 1.1 cents worth of silver at the present price. A copper undercoat would add 0.2 cent. Plating of commercial steel can be done at a cost comparable with that for base-metal finishing, it is claimed.

Seamless cylindrical can bodies and flat sheets for blanking the ends may be plated or, when a heavier silver coating is permissible, the can may be assembled from parts that are spun or domed, for example, using a rolled lock-seam. Non-returnable containers, where the main requirement is a silver coating, might be shaped before plating. In general, forming after plating, when the deposit is extremely thin, should be limited to a lock-seam or beading operation or simple forming that does not overstress the coating.

Drums or tanks can be silver lined by plating the cylindrical sheet before attaching the ends, and plating the ends before assembly. Lock-seaming does not damage the plate.

Design Considerations. If impossible to design a silver-plated container avoiding joining with heat, then silver brazing using inductive heating should be considered in laying out the design. Possibility of using corrosion resistant tin-silver alloy as solder should not be overlooked. A cold-rolled finished steel is preferable to hot-rolled finished material as a base metal.

Scrap value of silver is an important consideration when it is applied as a coating in returnable containers as well as in chemical processing equipment, storage tanks, and the like.

Welding and Brazing. The following methods may be used:

SILVER and silver-coated metals can be joined by fusion welding using fine silver rods, and by brazing with silver brazing alloys. Low melting points, malleability and ductility, high strength of joints, corrosion resistance, electrical conductivity and uniformity of joint are advantages of welding and brazing with silver and silver alloys. Brazed joints are possible without injuring plated finishes. Silver brazing alloys cost more than ordinary solders, but less alloy is required.

WELDING SILVER. Heat conductivity and oxygen adsorption make necessary rapid heating and protection of joint from oxidizing atmosphere. Good welded joint is achieved by preheating for some distance around joint and by using atomic hydrogen arc with fine silver welding rod.

WELDING CLAD METALS. Fine silver as filler rod on silver side, and usual types of welding rod on base metal give satisfactory welds of heavier gage clad metals. Principal consideration is to prevent contamination of silver and base metal. Atomic hydrogen arc is best, but carbon arc may be suitable. Oxy-acetelene torches will do if two torches are used, one traveling ahead for preheating. Other mechanical joints are necessary for thin gages of clad metals.

GAS BRAZING. Torch heating with silver brazing alloys gives high temperature, maximum flexibility, and speed. Air-gas torch is satisfactory for small parts; in large joints tendency is to run torch with oxidizing flame.

FURNACE BRAZING is advantageous for large number of small parts and for heating large, properly jigged assemblies. Controlled atmosphere is advised.

DIP BRAZING. Chemical bath (molten salt) is a quick method with accurate temperature control. Brazing alloy is preplaced, and part is dipped so that alloy is not immersed; joint is heated by conduction. Dip brazing is also done by metal bath, particularly suitable for joining small wires.

ELECTRIC ARC BRAZING, to a limited extent, has been used to repair heavy nonferrous castings with silver alloy as filler material.

HIGH-FREQUENCY BRAZING. This new and growing application of induction heating is now used principally in brazing noses on shells. Heating can be restricted to joint area, eliminating necessity for controlled atmosphere and eliminating warpage. Low-temperature brazing alloys are generally used.

RESISTANCE BRAZING. Incandescent carbon method with carbon electrodes is excellent for lap joints on small flat strips. Alloy is preplaced in joint. Advantages are rapid heating, easy control, and ability to confine high temperature to small areas. Jigs are not required if electrode pressure is sufficient to hold parts in place.

Question and Comment

Conical Springs

AUGUST BODENSCHATZ

The use of conical springs is not a common practice. This is probably due to lack of engineering information and the difficulties in adjusting machinery for winding them. There are occasions when conical springs best fit into a design. These conditions exist when axial space is limited and radial space is available.

The writer has come across a deflection formula which can be used for extension springs. The same formula will hold for compression springs as long as no coil of the springs pots; for until this condition is reached, the gradient of the spring has remained constant.

In order to know the characteristics of the load deflection curve of a spring the pitch of successive coils must follow certain laws. We consider first the spring in which all coils seat simultaneously at some predetermined load, which of course exceeds the useful load. The well-known formula (1) expresses deflection per coil and can be used to express the elemental deflection of the conical coil.

$$\frac{F}{N} = \frac{8\,PD^3}{Gd^4} = \frac{dF}{dN} \qquad (1)$$

N_t = total number of turns
F_t = deflection of entire spring
L = free length
P = load
G = modulus of elasticity in shear
$M = kGd^4$
D = mean diameter
d = wire diameter

We note that D, the mean diameter of the elemental section, varies for all sections, and must be given in terms of the variable N. Equation (2) expresses this relation in which N is the number of turns beginning from the left

$$D = (A + 2\,kN) \qquad (2)$$

Equations (3) and (4) naturally follow by substituting (2) in (1) and integrating

$$dF = \frac{8P}{Gd^4}\,(A + 2\,kN)^3\,dN$$

$$\int_o^{F_t} dF = \frac{4\,P}{kGd^4} \times \int_o^{N_t} (A + 2\,kN)^3\,d\,(A + 2\,kN) \qquad (3)$$

$$F_t = \frac{P}{M}\left[(A + 2\,kN)^4\right]_o^{N_t} \qquad (4)$$

Equation (4) gives the total deflection, P being taken as the load at which simultaneous seating takes place. For all other loads, deflections are proportional to the load. The deflection of any one coil, say (N) to $(N+1)$, may be found by use of (4) between limits $(N+1)$ and (N). If b is added to this deflection, we then have the pitch of that coil. If k is equal to or greater than d, b will be zero and the spring will be solid at length d. Equation (5) gives the free length of the spring.

$$L = F_t + bN_t + d \qquad (5)$$

This formula may be modified to common practice of having 1¼ solid coils at each end and ground. Then F_t should be for the limits $(N_t - 1\frac{1}{4})$ and $(1\frac{1}{4})$. For the ground ends, the d drops out entirely.

Another interesting problem is to design the spring so that seating occurs at the point in the wire where a predetermined stress is reached. By this we mean the spring begins seating at the large diameter progressively moving to the smaller end as the load increases. Here again we use the standard formula (6) from any handbook giving the load stress relation.

$$P = \frac{\pi\,S_{max}\,d^3}{8Y\,(A + 2\,kN)} \qquad (6)$$

S = stress
Y = Wahl stress factor

$$Q = \frac{\pi\,S_{max}}{6kYGd}$$

The Wahl factor has been included and an average value for the range of D/d ratio can be used in each instance. The value of P in (6) is substituted in (3) to form equation (7)

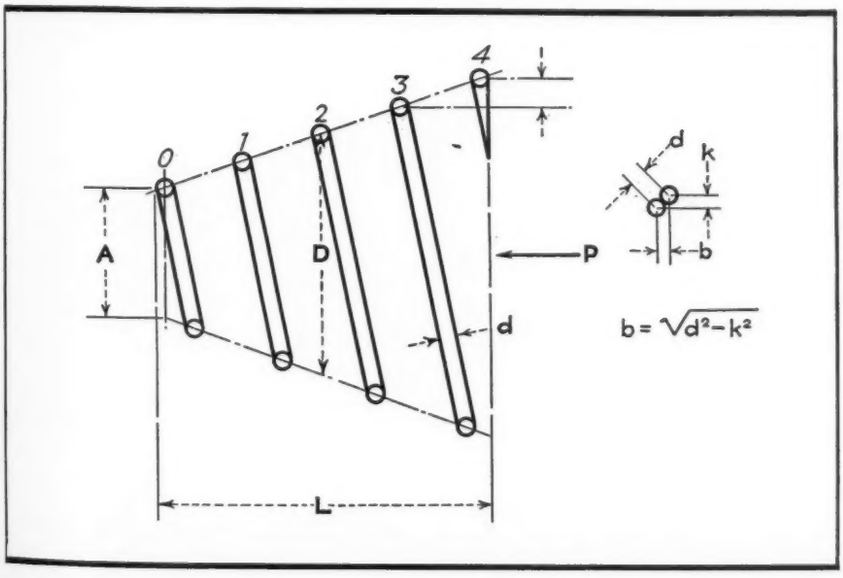
$$dF = \frac{\pi\,S_{max}}{Y\,Gd}\,(A + 2kN)^3\,dN$$

$$\int_0^{F_t} dF = \frac{\pi\,S_{max}}{2\,kYGd} \times \int_0^{N_t} (A + 2\,kN)^2\,d\,(A + 2\,kN) \qquad (7)$$

The free length of the spring may be found by using the value of (8) in equation (5). The deflection and pitch of any one coil are found in the same manner as explained above using values derived from equation (8).

$$F_t = Q\left[(A + 2\,kN)^3\right]_0^{N_t} \qquad (8)$$

The load deflection curve (P-F) may now be constructed as follows: Equa-



tion (6) is put into form (9) in which N_x is that point in the spring which divides it into the seated and unseated portions at load P.

$$(A + 2\,k\,N_x) = \frac{\pi\,S_{max}\,d^3}{8\,Y\,P}$$

or

$$N_t = \frac{\pi\,S_{max}\,d^3}{16\,k\,Y\,P} - \frac{A}{2\,k} \quad (9)$$

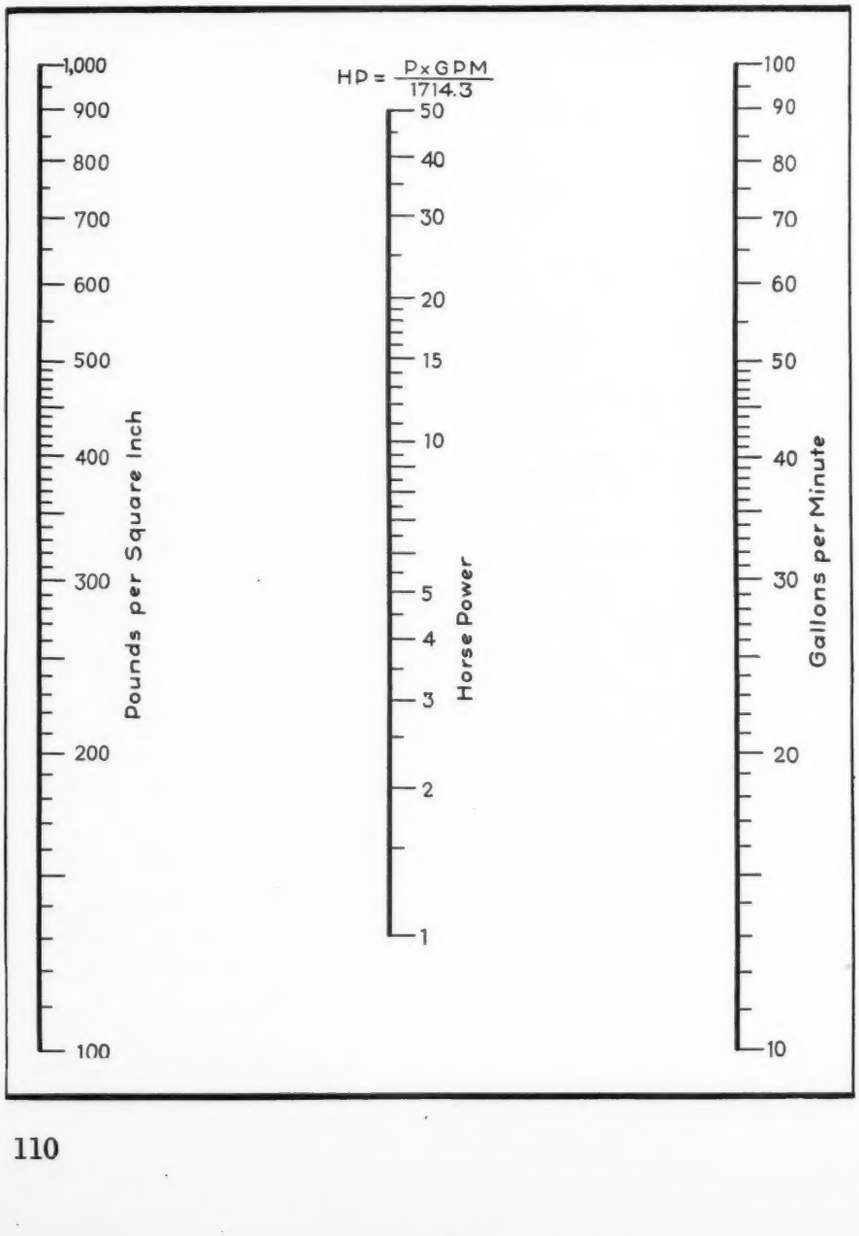
If N_x is greater than N_t the deflection will follow formula (4) and will be a straight line. If N_x is less than N_t the value of F (4) limits N_x and O must be added to F (8) limits N_t to N_x to get total deflection.

Nomogram Finds Power Required for Pumping

To the Editor:

Possibly the accompanying little nomogram may prove of some interest to your readers. It is a handy way to find the power requirements for a pumping problem. A straight edge connected between selected values on the two outer scales will give the necessary horsepower at the intersection of the center scale and the straightedge.

—George W. Schaeffer
Detroit, Mich.



Sulphur-Bronze Solder Fills Casting Blow Holes

To the Editor:

In the December number of Product Engineering, T. W. Kelley of Watertown, Mass., requests a solder the color of bronze for filling blow holes in bronze castings.

It is believed a solder made of fine powdered bronze and sulphur would fill the requirement. Such a solder is economical and has a comparatively low melting point. In addition, it can easily be made up in stock form by the user. Formula and instructions are:

1 lb. bronze powder
5 lb. sulphur

Melt sulphur in double boiler using motor oil in lower half of boiler, or in a granite ware dish under a fire-proof exhaust hood. Care must be taken to prevent flame from reaching sulphur. When sulphur is molten remove from fire and stir in bronze powder. After bronze powder is thoroughly mixed in, pour the mix into molds which are well greased to prevent solder from sticking. The mold usually used is of cast iron with 1 in. dia. cored holes. Holes must be polished smooth and nickel plated.

While the melting of the sulphur and mixing of the bronze powder in the molten sulphur is not a dangerous operation it must be handled with extreme caution by one who is familiar with it.

For best results it is recommended that the article to be soldered be brought up to a temperature which will just melt the solder and then the stick of solder rubbed over the section to be filled.

Since the binder of the solder is sulphur it has no strength. In the event a solder of greater strength is required I will be very glad to recommend a formula for a very strong metal solder similar to ordinary tin solder but having a reddish yellow color.

—E. J. Williams
Porter-Cable Machine Co.

"Stepped-Diameter Shafts" Procedure 3 Is Best

To the Editor:

I appreciated the excellent contribution of Mr. Puchstein on "Stepped Diameter Shafts" which appeared on pages 652 to 656 of Product Engineering for December 1941. The present writer has reviewed Mr. Puchstein's procedures 1, 2 and 3.

I note equation 21 as printed reads as follows:

$$\left(\frac{\triangle y}{\triangle x}\right)_n = \frac{M_n}{EI_n} + C_{1(n-1)}$$

It should read:

$$\left(\frac{\triangle y}{\triangle x}\right)_n = \frac{M_n}{EI_n}(\triangle x) + C_{1(n-1)}$$

The author's example, however, is worked out on the correct basis. In the present writer's opinion, procedure 3 is to be preferred over the other procedures for more practical engineering problems in which the provided results are as accurate as the data on which the problem is based, due to the many uncertain factors such as those listed by the author at the beginning of his article. Also, procedure 3 is of universal application. The double integrations

of procedure 1, while simple enough in the illustrated example, are often difficult for the variety of cases met in practice.

Both the author and PRODUCT ENGINEERING should be complimented on the care with which this article has been worked out and presented.

—ROBERT E. BRUCKNER
Vineland, N. J.

Can You Work This One?

H. E. SMITH

This month's problem—

Murder in Hoboken

A district attorney spent a sleepless night solving this one. See what you can do. A gangster named Bert Spanolli was murdered on a lonely road five miles from Hoboken at 3:30 o'clock on the morning of March 17th. A week later five men were arrested in Philadelphia and questioned about the murder. Each man made four statements of which three were true and one was false. From these statements, which follow, it can be determined that one and only one of the five was guilty. Which one was it?

Slim: I was in Chicago when Spanolli was murdered. I never killed anyone. Shorty is the guilty man. Red and I are pals.

Joe: I did not kill Spanolli. I never owned a revolver in my life. Shorty knows me. I was in Philadelphia on the night of March 17th.

Tony: Joe lied when he said he never owned a revolver. The murder was committed on Saint Patrick's Day. Slim was in Chicago at the time. One of us five is guilty.

Red: I did not kill Spanolli. Shorty has never been in Hoboken. I never saw Slim before now. Joe was in Philadelphia with me the night of March 17th.

Shorty: I did not kill Spanolli. I have never been in Hoboken. I never saw Joe before now. Slim lied when he said I was guilty.

Solution to January problem—

Allocating Nickel

From the statement that it makes a 25-lb. difference to *A* if he gets 20 percent more nickel than *B* or *B* gets 20 percent more than *A*, how much nickel the two companies had to divide is readily arrived at. If 25 lb. makes a 20 percent difference, *B*'s quantity, 100 percent, must be 125 lb. and *A*'s quantity, 120 percent, must be 150 lb. The total, therefore, is 275 lb.

[*Editor's Note*—Mr. Smith suggests that the problem can be made more intriguing by a slight change in wording. Let the 25 lb. difference depend on whether *A* gets 20 percent more than *B* or *B* gets 20 percent *less* than *A*. Now try to find the total poundage.]

Case Histories In Patent Law

H. A. TOULMIN, JR.

NO. 26

QUESTION: How are patent rights rented?

ANSWER: This is becoming an increasingly important question in view of the attitude of the Department of Justice toward patent licenses. Under the law as it now stands, an owner of a patent can decline to license anyone. If he does not choose to rent rights under his patents, he does not have to do so. If he wishes to rent them he can restrict the license as to territory, particular classes of trade and the price at which the licensee will sell the patented apparatus. This latter right is a very essential one because otherwise the licensee might completely ruin the patentee's business by selling the licensed product at a cut price.

This right has been firmly established by the Supreme Court of the United States in the case of United States v. General Electric, 272 U. S. 476, in which the Court said:

". . . as already said, price fixing is usually the essence of that which secures proper reward to the patentee.

"Nor do we think that the decisions of this Court holding restrictions as to price of patented articles invalid, apply to a contract of license like the one in this case. . . . They do not consider or condemn a restriction put by a patentee upon his licensee as to the prices at which the latter shall sell articles which he makes and only can make legally under the license.

"For the reasons given, we sustain the validity of the license granted by the Electric Company to the Westinghouse Company."

The Supreme Court has thrown another safeguard around patent rights in a recent case in which it held that if a licensee was rented the right to use a radio tube for a specific purpose, that any purchaser from a licensee who used those tubes for another purpose, would be an infringer. The Court said in General Talking Pictures Company v. Western Electric Company, 304 U. S. 175:—

". . . The Transformer Company's license was expressly confined to the right to manufacture and sell the patented amplifiers for radio amateur reception, radio experimental reception, and home broadcast reception. It had no right to sell the amplifiers for use in theatres as a part of talking picture equipment."

"The Transformer Company could not convey to petitioner what both knew it was not authorized to sell. . . . By knowingly making the sales to petitioner outside the scope of its license, the Transformer Company infringed the patents embodied in the amplifiers. . . . Petitioner, having with knowledge of the facts bought at sales constituting infringement, did itself infringe the patents embodied in the amplifiers when it leased them for use as talking picture equipment in the theatres."

An interesting case arose a few years ago in the optical field. The owner of the optical patents licensed a licensee in each territory. One of these licensees proceeded to ship into the territory of another licensee and was promptly held to be an infringer as his rental rights only extended to his own territory and outside of that territory he was an infringer.

Rental or license agreements are complicated documents which must be drafted with great care and with a full knowledge both of the trade, how it operates, the business procedure as to the accounting of royalties, the accounting basis for fixing royalties and the thousand and one details of a complicated, successful patent license system. For instance, such questions as when the royalties are to be paid, whether it is a flat sum or percentage, who is to have the right to bring suit against infringers under the licensed patent, the term of the license, its territory, the marking of the licensed product or machine, are some of the important questions that have to be decided.

News and Summaries

Substitutes Readily Available For Cork's Many Uses

ALTHOUGH CORK is a widely useful material to American industry, cessation of imports due to war will not seriously hamper industries using this material. Almost all of the world's supply comes from the area comprised by Spain, Portugal and North Africa, and, while war has not yet cut off this source area, substitutes are ready to take over for cork if imports are cut off. A tree must be 30 to 40 years old before it produces cork and 8 to 10 years elapse between strippings so that no attempt can be made to grow trees in this hemisphere for immediate use.

About 60 percent of our consumption of cork goes into insulation products such as corkboard, cork pipe covering, granulated cork, acoustical corkboard and so forth. Such products are made from second grade cork and scraps. They are ground, heated and compressed to bind the particles together. The resultant product is probably the most satisfactory for low temperature insulation but many excellent substitutes exist. Among them are Rock Cork, fiber board, felt, glass and mineral wool, sponge rubber, sawdust and many others. All are commercially available.

Some cork is used to make cork tile, a resilient flooring also used at times as a wall covering. Such a use can be eliminated entirely and needs no substitute.

Approximately 27 percent of consumption goes into bottle cap liners, gaskets, washers and similar products. These are made of composition cork which is composed of small cork particles held together by the use of an adhesive binder such as glue, gelatin or synthetic resins.

While substitutes have not been adopted to any extent as yet some adequate materials have been developed. Paper board pulp coated on both sides with Pliofilm makes a satisfactory bottle cap liner and so does a flowed-in rubber latex composition using a mineral filler. Machines are already being produced to manufacture the latter type. No changes in bottling machinery would be required by either type.

Cork gaskets are now used only for sealing oil enclosures. Impregnated paper gaskets are used to stand the heat of engines. Substitutes for cork gaskets generally require the inclusion of synthetic rubber to resist oil deterioration. One estimate states that one million cars would require about 100 tons of this strategic material. Some compositions have been achieved which do not use synthetic rubber but do use a percentage of cork. Manufacturers feel, however, that cork can be satisfactorily replaced.

The 10 percent of consumption going into linoleum could be almost completely eliminated by use of other floor coverings except for certain special applications such as in battleships.

The remaining 3 percent is used for items as life preservers, shoe parts and bottle stoppers. Cork for marine use will probably be disturbed last of all. It may be said then, that while cork is very useful throughout American industry its elimination can be achieved with no serious dislocations of any sort.

Giant Cathode-Ray Screen for Demonstrations

RECENTLY ANNOUNCED was this new giant cathode-ray oscillograph which was developed for lecture-room demonstration and for the more critical laboratory studies.

Known as Type 233, this latest DuMont oscillograph utilizes the DuMont 20-in. diameter intensifier-type cathode-ray tube with medium-persistence green screen. The final accelerating potential of 6,000 volts provides a high-intensity spot of good resolving power, so that a highly-detailed trace may be observed even in well-illuminated rooms by a large group. The instrument consists of the 20-in. cathode-ray tube; amplifiers for signal deflection along both X- and Y-areas, and for Z-axis or intensity-modulation signals; a linear-time-base generator and associated power and control circuits.

A beam switch is provided to permit stand-by operation of the oscillograph. It serves to switch the bias on the grid of the cathode-ray tube from normal operating values to a value which will cut off the beam, without disturbing the settings of other controls. In this manner the spot can be turned off with the instrument in "stand-by" condition, thereby avoiding the long concentration of the spot at a given point, which might cause "burning" or discoloration of the screen.

The instrument is completely self-contained and can be operated from a single-phase source of 50- to 60-cycle power at 115 volts. Power consumption is approximately 350 watts. The sturdy metal gray wrinkle-finish cabinet measures approximately 28 in. wide, 36 in. deep and 60 in. high. It is mounted on rubber-tired, locking casters. The total weight of the instrument is 325 pounds.

Screen of this giant DuMont Oscillograph can be seen by a whole lecture group

Nylon Beneficial As Electrical Insulation

NYLON'S QUALITY as an electrical insulator makes it possible to manufacture motors which require 10 to 15 percent less coil space than motors of identical capacity which use the conventional enamel magnet wire insulation, according to a recent announcement by the du Pont Company. This results in a corresponding saving in such vital core materials as iron.

The nylon wire insulation, which is

applied like enamel, may be used for motors for small power tools, fans, vacuum cleaners, refrigerators and for ignition coils, voltage regulators and numerous other industrial and household appliances.

Nylon insulation is said to be resistant to abrasion and cracking, to have good dielectric strength and to be unaffected by any conditions of moisture, temperature, compression or chemical action which may normally be encountered.

Wool Felt An Important Defense Material

THE WOOL FELT INDUSTRY shortly will inaugurate an educational campaign calling the attention of the public to the widely diversified uses for wool felt. Not only the average person but even many manufacturers of standard articles as well do not realize the importance of this centuries-old product in the Defense program. An overwhelmingly large percentage of fabricated articles in both civilian and military use contain felt in their make-up and it is now being used as a substitute for rubber which faces a serious impending shortage; also for certain textiles, plastics, cork, leather, wood and other materials.

Without felt to absorb vibration, flying-fortresses and clipper ships would not be nearly as efficient as they are. Without its use as padding and as bearing surfaces and cushioning for gun turrets in fighting planes, as well as in tanks and artillery, there would not be such accuracy in firing. The metal helmets of the army are now being lined with felt, as are heavy overcoats. Processed into hard, circular buffing wheels, 100 percent wool felt is used to polish lenses for military and naval use and for photography. For the operation of stationary machines it is used increasingly in mountings to absorb vibration.

Felt is said to be unequalled as a retainer of lubricant in moving machine parts and its use as insulation in air-conditioning and heating equipment is extensive.

4-lb. Radio Receiver and Transmitter

A COMPLETELY self-contained radio telephone combination transmitter and receiver weighing only four pounds, and not much larger than the handset of a "French" telephone, which it resembles, has been announced by the Communications Division of Weltronic Corporation. The unit is being made available to governmental agencies and services, including municipal divisions, public utilities, fire and police departments, railroads and other transportation agencies, as well as individuals, subject of course to licensing by the Federal Communications Commission where required.

The built-in battery power supply for the new Weltronic "Trans-Ceiver" under continuous operation has a rating of about 8 hours. This is equivalent to approximately a week to a month's operation under 'normal' intermittent service. The power supply is derived from standard commercial batteries in order to keep battery replacement cost at a minimum and facilitate maintenance of operation.

With a range upwards of a mile over land, the units are provided with off and on switches and finger operated selector to change from transmitting to receiving and vice-versa, while talking through the unit.

Although the Weltronic "Trans-Ceivers" are designed for operation on a single wave length, thus requiring no tuning in service, their frequency range is adjustable from 112 to 300 Megacycles through a simple externally accessible screw adjustment.

Also provided on the units are a volume control and a detachable adjustable short fish-pole type of aerial.

Do You Know That—

A new type glass cutter is being brought out to cut curved lines. It is shaped like a pair of cutting pliers with specially designed, hardened jaws. (3)

Tractor tires give a firmer grip in farm operations if filled with water rather than with air. (4)

Perkin Medal Presented to Dr. Ittner

THE PERKIN MEDAL for 1942 was presented on Jan. 9 to Dr. Martin H. Ittner of the Colgate-Palmolive-Peet Company at a joint meeting of the American Section of the Society of Chemical Industry, the American Chemical Society, the American Institute of Chemical Engineers, the Electrochemical Society and the Societe de Chimie Industrielle. The medal, which is awarded annually by the American Section of the Society of Chemical Industry for outstanding work in applied chemistry, was presented by Dr. Marston T. Bogert, following which Dr. Ittner gave an address on the subject "Forty-five years of Chemistry in a Soap Plant."

For almost 45 years Dr. Ittner has been in charge of research at Colgate-Palmolive-Peet Company or predecessor companies. Among Dr. Ittner's many contributions is his development of a successful commercial process for the hydrogenation of fatty oils, on which process he has been granted a number of patents. He has also made valuable contributions in the field of distillation and he holds several recent patents pertaining to new processes for glycerine production and fatty acid distillation. He holds patents for the countercurrent hydrolysis of fats with water

Meetings

American Institute of Mining and Metallurgical Engineers — Annual Meeting, Engineering Societies Building, New York, N. Y. Feb. 9–12.

American Society for Testing Materials—Committee Week and Spring Meeting, Mar. 2–6, Hotel Cleveland, Cleveland, Ohio.

American Society of Mechanical Engineers—Spring Meeting, Houston, Texas, Mar. 23–25. C. E. Davies, secretary, 29 W. 39th St., New York, N. Y.

Aeronautical Lending Library Endowed

AN ENDOWMENT FUND of $65,000 has been established by Paul Kollsman, founder of the Kollsman Instrument Company, and given to the Institute of the Aeronautical Sciences to maintain a library for lending aeronautical books to anyone interested in bettering his knowledge of aviation.

As the library is scientific in scope, this gift comes at an opportune time when hundreds of thousands of workers are engaged in the government's huge aircraft construction program and the armed services have called for thousands of aviation cadets each month. Those who want to broaden their knowledge of aviation can borrow books from the library by mail without charge.

In 1940, Mr. Kollsman and the Square D Company of Detroit underwrote the upkeep of such a service. This has been so valued by students and engineers that Mr. Kollsman wished to make the fund permanent.

ENGINEERING IN WASHINGTON

McGRAW-HILL WASHINGTON BUREAU, *PAUL WOOTON, CHIEF*

Standardization of aircraft is out of Army and Navy talk stage into reality. All through the war, as before, we tried everything possible, with other people's battles as the best of all laboratories. Now we are freezing design. Models are dropped without announcement, but you will miss them in the news. One well-known ship, in wide use, is already out and the manufacturer is taking his competitor's design in for production. Another one is on its way out. Both have many fine characteristics, but other planes in their category have less faults.

Freezing for action means more production pools, like the Boeing-Lockheed-Vega pool, the four-plant automobile parts assembly pool, and the aircraft engine pool. More and more combinations building one plane will be formed. Greatest of these combines will be in the automobile industry. We haven't seen anything big yet; to meet the President's quota of 60,000 planes in 1942, we must go from where we are now, somewhere above 2,000 per month, to about 7,500 per month in order to average 5,000 per month.

Fortunes of war have put Germany in an awkward position regarding aircraft. The Nazis developed some fine airplanes up to 1936 and 1937, and they put them into production for a quick victory. The victory didn't come. Meanwhile, the United States, and other countries to a lesser degree, went from Germany's freeze point forward. With the result that Germany is now desperately working on development of new models to meet the threat of ours. They have a few new ships, but not enough good ones to meet Boeing and Consolidated heavy bombers, our Airacobra and Republic fighters for low and high altitude respectively, our Martin and North American medium bombers, and others—some 15 top notch planes in all. Meanwhile, the United States, with its vast manpower, can spare enough engineers to go right ahead with full-scale development of new planes.

Concrete bases for heavy machine tools, to take the place of cast iron, is being considered by engineers in OPM. By bases they mean the lower portions of the machines; and possibly the uprights, or posts, of some of them could be included. They mentioned boring, milling, and planing machines. The function of the bases, while they must have strength, is mainly weight and elevation of the work to convenient height. It is doubtful if application of cement would be considered for high speed operations. The engineers said they believed that properly reinforced concrete might do the job.

500 wooden barges have been called for by the Maritime Commission and bids are invited for 50 to 100 such vessels. The craft would be of the "non-propelled deck-cargo" type, 60 ft. long, 8 ft. wide, 5 ft. depth, and with a carrying capacity of 99 short tons. Mass production was called for by the time limits, which require delivery of the first barge at either New Orleans or Mobile in not more than 30 days from date of contract, and the last in not more than 110 days.

Father of the submarine, inventor Simon Lake, has reminded Americans who were surprised at discovering midget Japanese submarines slipping about Pearl Harbor, that he had developed a two-man submarine in 1901, and had submitted it to the Navy which rejected it. The Japanese lost three in the attack at Pearl Harbor, at least one of which was recovered by American naval authorities for examination. The Jap subs are 41 ft. long, 5 ft. beam, with a low conning tower, and about 24 knots estimated surface speed. They were believed to have a 200 mile cruising radius, and the one captured made a run of 100 miles from a parent ship. Made of ¼-in. plate, the sub carried two 18-in. torpedo tubes, which compares with the standard 21-in. American type on destroyers. The Navy gives no hint about working on similar craft.

"Tank-killers" is the term assigned to a new type of anti-tank unit developed by the United States Army after trials in maneuvers. The mobile unit comprises virtually a rolling fortress, with six independently spring-mounted wheels on each side, 30 ft. long, 7 ft. high, traveling 80 m.p.h. on the highway, and armed with one 75-mm. gun, and two .50-cal. machine guns. Some 53 battalions built around these weapons are to be added to the army with plans for 144 eventually.

Substitutes for 800 materials specifications have been developed by the War Department. In many instances where galvanizing has been the standard finish, zinc is being conserved by using paint, porcelain enamel, synthetic enamel, and black japan as the finish. As a base material in a few Quartermaster procurements, zinc is being replaced by galvanized iron or steel. As a substitute for nickel plating, paint or synthetic enamel is being widely used and bronze or porcelain finishes are being used in place of monel metal, containing much nickel. Oxidizing, clear lacquer, brass or copper plating, and Parkerizing, process in which the metal is dipped in a hot zinc oxide solution, are all being used instead of cadmium plating.

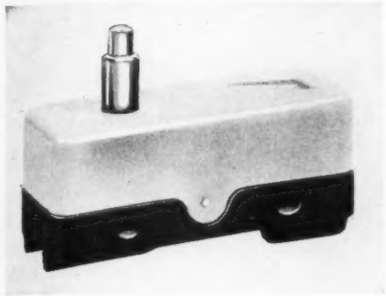
Steel, cast iron and malleable iron are being used as substitutes for aluminum. Since steel has also become a critical material, a number of substitutes for it have been added to Army specifications. Among these are concrete, gypsum, wood, plywood, ceramic ware and galvanized iron. For the conservation of aluminum, the Quartermaster Corps is now testing experimental vehicles equipped with cast-iron pistons. The added weight caused by this substitution increases the load on the bearings and affects the power of the vehicle, which may necessitate the re-designing of the motor. If the experiments prove successful, from 3 to 23 lb. of aluminum alloy will be saved in the manufacture of each new Army truck.

Synthetic rubber program, says Dr. E. R. Weidlein, chief of Chemicals Branch of OPM, should be possible through pooling of patents, resources, experience and skills of rubber, chemical and petroleum industries. Enough raw materials are now in sight for half the program. Basic ingredients for "Buna S" type adopted as standard are butadiene and styrene. If high priority ratings are assigned for stainless steel equipment, first 200,000 tons capacity will be in production by the end of 1942. If raw materials question, now being discussed, is cleared up by July this year, the second 200,000 tons capacity can be ready by the middle of 1943. Experimentation will go on during production, with present outlook for a product 95 percent as efficient as crude rubber.

New Materials and Parts

Overtravel Type Switch

Overtravel of at least $\frac{1}{8}$ in. is now incorporated in a line of Acrosnap switches. Travel for actuation remains at 0.001 in. as in the standard pin plunger type. Switches are rated at 10 amp., 115 volts a.c. with a maximum wattage of 1,000; 5 amp., 250 volts a.c., with a maximum wattage of 1,000; 3



amp., 450 volts a.c. at 1,000 watts. Pressure on the spring can be had from 3 to 14 oz. The unit weighs approximately 1 oz. and measures $1\frac{15}{16}$ x $\frac{11}{16}$ x $\frac{27}{32}$ in. For added strength a large shank is on the button. Acro Electric Co., 3176 Fulton Rd., Cleveland, Ohio.

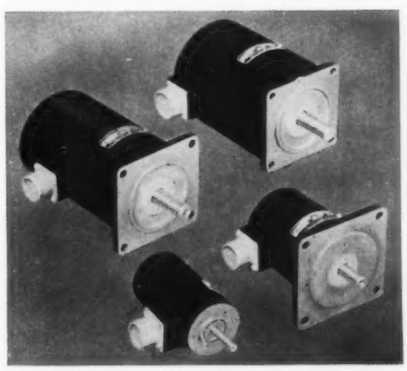
Paints for Civilian Applications

To replace unavailable aluminum paints, the "Defense Line" of five paints has been produced for both new construction and maintenance applications. Valdura Tank White, with a reflectivity factor from 10 to 15 percent higher than that of aluminum paints, will replace the latter in applications where it is desirable to cut evaporation losses and reduce inside temperature. Resistant to oil and water, it will cover, with brush or spray, about 450 sq. ft. to the gal. Valdura Metal Lead Paint gives to all metal surfaces a protective, lead-colored metal coating resistant to acids, alkalies, fumes, rust and moisture. It sets in from 2 to 3 hr., dries in 10 hr., and resists temperatures up to 225 deg. F. Rated coverage is approximately 600 sq. ft. of clean metal per gal. It may be used as a general metal primer under any paint except those containing asphalt. For low-cost protection of exposed metal surfaces, two Valdura Defense Grays are also listed. Claims include permanent elasticity in the paint film and high resistance to rain, sun, grime, smoke and rust on outdoor structures subject to large temperature variations. Designed particularly for use where metal is subjected to conditions of extreme moisture, Valdura Enamelized Yellow Metal Primer may be applied on all metal surfaces. Its light yellow color permits a single coat of paint to hide the primed surface. Coverage is 500 sq. ft. to the gal. American-Marrieta Co., 43 E. Ohio St., Chicago, Ill.

Motors for Aircraft Service

A line of motors in fractional-horsepower frame sizes has been produced for aircraft service. Designated as Type BA-25, -40, -50, and BC-21, -31, these direct current motors are furnished as series, compound, or shunt wound motors with ratings ranging from 0.005 hp. at 7500 r.p.m. continuous, open, to 7 hp. at 7500 r.p.m. totally inclosed, no cooling air over the motor, one minute intermittent duty. They are available in five standard speeds, 1750, 2800, 3800, 5800, and 7500 r.p.m., although other speeds may be furnished. Motors can be supplied in either 12 or 24 volt construction. Frames are of aluminum although magnesium castings may be used where weight must be held extremely low, and features include bolted-in pole pieces, precision balance, all ball bearing construction, and standard air corps flange mountings in styles Nos. II, III and IV. Although standard shaft extensions are plain, they may be obtained with cut spline or other special features.

Motors are equipped with AM-3102 connectors, but leads can be brought out to the sides of the motor and held in



place by a rubber plug if necessary. All types for either grounded or ungrounded wiring systems may be obtained. General Electric Co., Schenectady, N. Y.

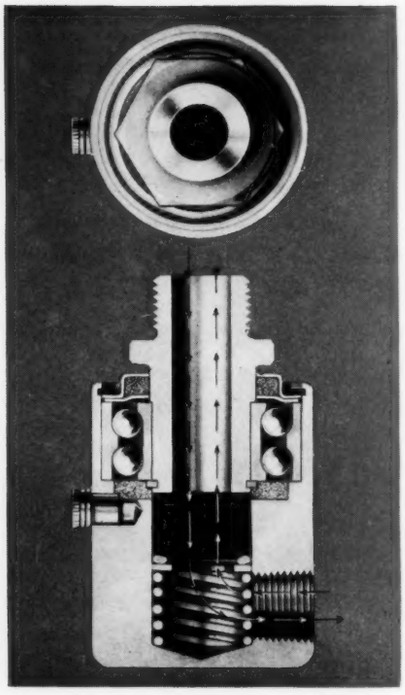
Protected Motor

Cast as part of the frame, a wide rib forms an unbroken circle of protection around the stator. One-piece cast frame and cast end-shields guard the motor from exterior knocks and abuse. Also in this new line, a liberal use of materials makes these motors mechanically and electrically stronger because current

and magnetic densities are less extreme. Bearing design has been improved for full flow lubrication and easy maintenance. Rotor is keyed to the shaft, and is turned to obtain accurate airgap. Other features of the Lo-Maintenance motors are oil drains at bottom of bearings for easy flushing; removable end-brackets; and large conduit box. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Rotary Oil Seal

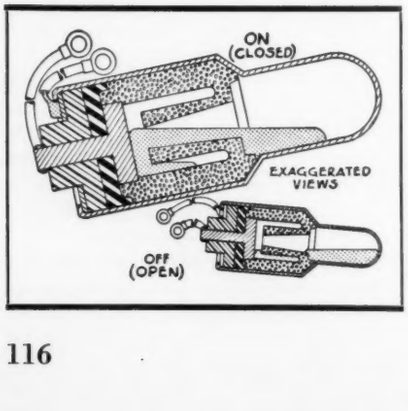
"Rotorseal" is a device which acts as a positive seal at the point of transmission when air or oil, under pressure or vacuum, is transmitted from a stationary member to a rotating member or vice-versa. It consists of a shaft rotating in a sealed double row ball bearing mounted in a housing, the seal of which is achieved by a special non-metallic seal nose bearing against the face of the rotating shaft. A spiral spring provides self-adjustment for the lapped bearing surfaces to compensate for wear and maintain a constant, positive seal with minimum friction, Rotorseal



can be run continuously in either direction, and reversed as often as necessary at pressures up to 150 lb., temperatures up to 200 deg. F., and speeds up to 2,000 r.p.m. It comes in five sizes, with passages ¼ in. to 1½ in. Kellog Div. of American Brake Shoe & Foundry Co., 97 Humboldt St., Rochester, N. Y.

Mercury Switch

The peculiar characteristics of this "Double Flow" switch are said to make it highly resistant to vibration. Two streams of mercury pulling in opposite directions, until severed over a ceramic barrier, prevent double contacting where vibration exists. When closing, the two approaching bodies of mercury pile up a double thick electrical conductor. It is claimed that the switch works equally well whether opened with a slow rolling motion or with a high speed mechanical snap action. Switches are housed in an unbreakable metal case and are available in 10, 20, 35 and 65 amp. sizes. Durakool, Inc., 1010 N. Main St., Elkhart, Ind.

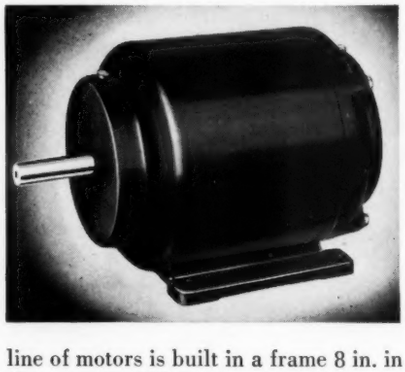


Welded Stainless Tubing

Electrically welded stainless steel tubing having high resistance to corrosion, strength with minimum weight, and uniformity of structure will be marketed under the trade name of "Gloweld." As the stainless strip is welded in such a way as to result in a tube with very little "flash" the amount of grinding or cutting off of flash to obtain a smooth finished tube is reduced to a minimum. The manufacturers say that as the weld metal closely approximates the structure of the tube itself, this tubing can be readily bent, coiled, swaged and formed. Strength at high temperatures and low comparative cost are among advantages claimed. As well as in a wide range of diameters and wall sizes, tubing will be furnished in practically all the stainless steel analyses. Globe Steel Tubes Co., Milwaukee, Wis.

Streamlined Motor

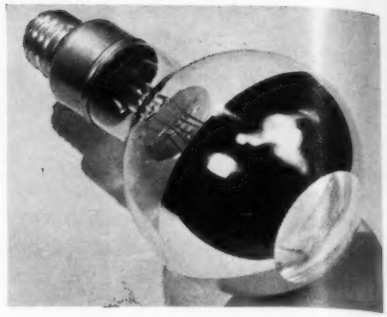
Smaller in diameter and length than the standard NEMA motor of similar power, a line of streamlined motors has terminal box at the bottom, or at either side, top or an angle if desired. This



line of motors is built in a frame 8 in. in diameter by 10⅜ in. long, and in sizes ½ to 2 hp. in all standard speeds. They are polyphase AC motors. The Ohio Electric Mfg. Co., 5900 Maurice Ave., Cleveland, Ohio.

Packing of Synthetic Rubber

Qualities claimed for a newly compounded synthetic rubber, which can be made in various shapes and sizes of packing and other molded and extruded parts, are exceptional oil resistance, flexibility and ability to seal pressures at extremely low temperatures. Such packings are recommended particularly for aircraft use and wherever there is a wide variation of temperatures. The Monarch Rubber Co., Hartville, Ohio.



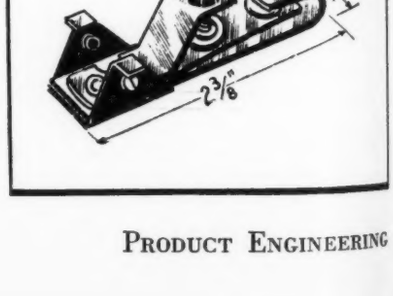
Infra-Red Heat Lamp

A recent development in infra-red heat lamps consists of a ring lining of silver inside the bulb at a point just below the focal point of the filament. This is said to eliminate the 25 percent loss of heat rays characteristic with ordinary bulbs. The ring leaves a clear "bullseye" spot through which heat beams are projected.

To keep the bulb from loosening up under the high heat developed in infra-red tunnel installations, it is manufactured with mechanical strap-in base. In the 250-watt size, tungsten filament only, the new bulb will fit the standard Edison screw socket and has an average burning life of more than 5,000 hr. Wabash Appliance Corp., 335 Carroll St., Brooklyn, N. Y.

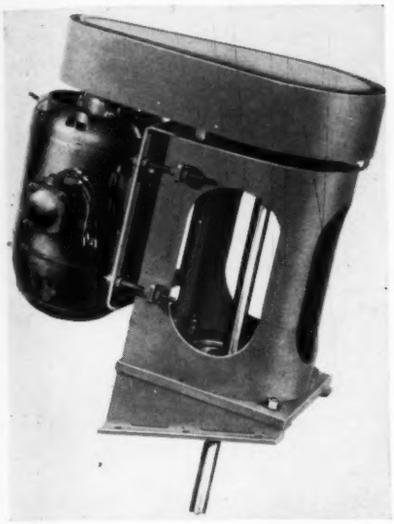
Thermostat

A recently developed thermostat, Type ASK-BB, is provided in three units with maximum operating temperatures of 300 deg., 450 deg., or 700 deg. F. With large silver contacts, the assembly comprises a ½ in. bi-metal element, mica-insulated from a ½-in. spring. Two insulated mounting holes complete the assembly. The unit is capable of handling 1500 watts, at 150 or 230 volts a.c. It can be supplied in either normally open or normally closed type. Temperature setting is increased by turning adjusting screw clockwise. Manufacturers recommend the use of this thermostat on electrically heated cabinets, flat irons, rubber vulcanizing equipment, radio transmitters, etc. George Ulanet Co., 88E Kinney St., Newark, N. J.



Mixer With V-Belt Drive

This top entering propeller type mixer is equipped with V-belt drive for such applications as open tanks, closed tanks, pressure or vacuum vessels and for attachment to standard size nozzles. Feed can be changed by changing the sheave and pulleys, or variable speed pulleys can be provided on the motor which allows approximately 25 percent speed variations, from 400 to 600 r.p.m. Mixers can be furnished with electrically conducting belts to do away with danger from static electricity in hazardous locations. Oil resisting belts can



also be furnished when necessary. Motors, in standard horizontal NEMA frame can be standard, semi-inclosed, drip proof or totally inclosed, air jacketed, or explosion proof as required for service. Shaft and impellers are selected according to the materials being mixed, and can be made from any machineable metal or alloy. Units range in size from 1 to 25 hp., and may be mounted in any desired fashion on any size or shape tanks. Mixing Equipment Co., Rochester, N. Y.

Dust Collector

A new dust collector having a rating of 600 cu.ft. per min. is designed to exhaust pedestal, bench and surface grinders, cut-off machines, etc. Known as the "Dustkop 600" it is equipped with a ¼ hp., 3450 r.p.m., 110 volts a.c. continuous duty single-phase motor to provide a water lift of approximately 3.3 in. It can be mounted on a grinder, or on the floor behind the machine. When connected with tool grinders, the unit comes with a two-way intake flange. Two lengths of 2-in. flexible rubber hose complete the connection between the unit and the wheel hoods. An intake flange to accommodate a 5 in. pipe elbow is supplied when the unit serves only one wheel. Dust and dirt collected are removed by lifting the louvered cover, taking out the filter assembly, and removing the pan into which dust has fallen. Filters of the spun glass variety are said to stop over 99 percent of the dust and are quickly renewable at low cost. Aget-Detroit Mfg. Co., Detroit, Mich.

Blackout Paint

For darkening plant windows and skylights, a paint is now marketed in paste form which may be cut 50 percent with water, sprayed or brushed on glass to prevent all passage of light. Coverage is 800 sq. ft. to the gallon. It dries within 40 minutes, leaving a black surface that does not glare when hit by artificial light. In interior applications a single coat may be covered with white paint where the reflection from large glass surfaces is needed for illumination. Called Valdura Blackout, the paint may be removed from glass without damage. American-Marietta Co., 43 E. Ohio St., Chicago, Ill.

Cellulose Acetate Tubing

Tubing of ⅛ in. to 3 in. inside diameter, in assorted gauges, is made of Lumarith Protectoid in round, oval and square shapes, and in continuous lengths that can be cut to required sizes as it emerges from the winder. It is available in clear transparent form, or with a paper or fiber base having an outside layer of the Lumarith Protectoid. Some of the uses of this material are as cores for speaker field coils, in bobbins, for random wound

ignition coils, spaghetti insulations for wire, and for protection of delicate metal parts such as micrometer handles. Celluloid Corp., New York, N. Y.

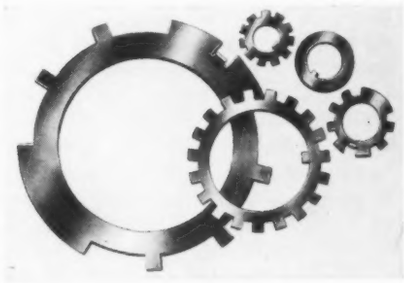
Control Stations

A new series of Class 9001, Type M pushbutton stations and inclosures is available for 3, 6, 9, 12, and 16 pushbutton, selector switch, or pilot light control units. Each may be furnished as an assembled station or as an inclosure only. Closing plate assemblies are provided for unused openings in the coverplate. Inclosures consist of a cast

iron case, gasket, and steel coverplate designed to accommodate standard control units. Square D Co., 4041 Richards St., Milwaukee, Wis.

Custom Made Lock Washers

With a special die stamping process, the manufacturers claim the production to definite requirements of 100 custom made lock or thrust washers from various sheet alloys at a cost no greater than that of 6 or 8 hand made washers. Present capacities are said to range in



diameter sizes of from ½ in. to 12 in. of any alloy sheet that can be die stamped. A special compound die is used. Dayton-Rogers Mfg. Co., Minneapolis, Minn.

Books and Bulletins

Plastics Reference Library

Three volumes, Index, one-year supplemental bulletin service. Published by Plastics Industries Technical Institute, 186 S. Alvarado St., Los Angeles, Cal. Price $125.

Compiled to be the most complete collection of information on plastics, these three volumes are classified and indexed so that the answers to almost any plastic problem can quickly be found. All types of materials and all phases of the industry are covered. The material is easy to read, logical in thought, and is arranged for quick reference.

The data were written and compiled by men with long experience in the plastics industry, under the direction of John Delmonte and E. F. Longee, and were originally prepared as lessons for an extension course of the Plastics Industries Technical Institute. Printing of the volumes was done by photo-offset. Actual samples of the various types of plastics molding and laminating materials are bound in with the text.

In addition to the three major volumes of the reference library, a one-year supplemental bulletin service will keep the data up to date. Supplements will be published once every month. A subscription to *Plastics Trends* also is included.

Principles of Electron Tubes

HERBERT J. REICH—*408 pages, 6x9 in., illustrated. Green clothboard covers. Published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N. Y. Price* $3.50.

While basically an abridgement of a longer work by the same author, this book is intended for those who do not specialize in communication engineering. Beginning with a presentation of the elementary principles of electronics and the laws and factors governing thermionic emission, it continues with chapters on the structure and operation of high-vacuum tubes and circuits. To reduce complexity of theory several simplifying assumptions are made, but references to rigorous treatments are included. The treatment covers the field well and always includes references to advanced analyses of structures and circuits.

Over 100 pages, however, are devoted to the theory and application of various discharge tubes, thyratrons, ignitrons and so forth, and to photo-sensitive tubes. One chapter describes the power tubes and glow tubes and emphasizes methods of control for different uses, such as for rectifiers and welding controls. Another chapter, after surveying the theory of photo-electric phenomena, gives prominence to characteristics of and circuits for phototubes, although photo-voltaic and photoconductive cells are also covered. The material throughout is clearly explained and well illustrated.

Properties of Metals At Subatmospheric Temperatures

H. W. GILLETT—*112 pages, 6x9 in. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Price* $2.50.

This little volume represents an enormous amount of work performed by many laboratories and considerable material from existing literature on the subject, all classified and discussed by Dr. Gillett. There are 142 tables of data included, covering impact and tensile data for both ferrous and non-ferrous metals. The tables are accompanied, however, by information on test limitations and the reports and suggestions of other observers. Limitations of present knowledge and testing methods are clearly pointed out. The result is as full and complete a treatment as is now available on this subject.

A.S.T.M. Standards 1941 Supplement

Part I—Metals, 619 pages. Part II—Non-metallic materials, constructional, 449 pages. Part III—Non-metallic materials, general, 663 pages. 6¼x9¼ in. Blue leatherette covers. Published by American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Price (to non-members) $3 *one part,* $5 *two parts,* $7 *three parts.*

Completing their publication of the Book of Standards begun in 1939, the A.S.T.M. has just issued this three volume 1941 Supplement, adding another 370 standards and tentative standards to round out the task. With the books come stickers showing changes in the standards published in 1939 and 1940 and intended for pasting on the pages of those books. With the books also comes the 196 page Index which provides a handy reference to the entire three years' work and also gives all serial designations in numerical order.

Plastic Molding

D. A. DEARLE—*8 illustrations, 131 pages. Blue clothboard covers. Published by Chemical Publishing Co., Inc., 234 King St., Brooklyn, N. Y. Price* $4.

Written as a comprehensive study of the plastics molding plant, this just-published book contains four chapters on equipment, management and merchandising which the design engineer can afford to skim over, but the remaining chapters give the designer much background information for the design of plastic parts. One chapter of particular value details the principal considerations of mold and parts design, covering such items as die construction, metal inserts, shrinkage, lettering and product engineering. Other chapters give the history of plastics, describe briefly the various plastic materials, and explain molding and finishing techniques.

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Inspection and Tolerances for Gears

10 pages, 8½x11 in. Mimeographed sheets. Issued by American Gear Manufacturers Association, J. C. McQuiston, manager-secretary, 602 Shields Building, Wilkinsburg, Pa.

This tentative standard titled "Recommended Practice of the American Gear Manufacturers Association for Inspection and Tolerances for Gears, Part I—Spur and Helical Gears, revised October 1941," is intended to form a practical basis upon which gears can be manufactured, inspected, sold or purchased. Four classes of gearing are listed according to use. The fundamental errors of gear teeth for which tolerances are given are: Runout, pitch error, accumulated error, profile error, and lead error. Each is defined and explained briefly. Inspection tolerances for the five errors are given in chart form.

Outline of the Metallurgy of Iron and Steel

HARRY K. IHRIG—*third edition, 80 pages, 6x9 in., blue buckram covers. Published by Globe Steel Tubes Co., Milwaukee, Wis.*

Written in a forthright manner, this outline will provide both shop foremen and engineers with a ready reference for their questions on elementary metallurgy. In a progression from cast iron through heat and corrosion resisting alloys, the book takes up the properties of various irons and steels as well as the methods of their manufacture. Altogether, it is easy and educating reading for the person not too well grounded in knowledge of iron and steel.

AIRCRAFT WELDING

Strength of Fusion Welds

R. R. WIESE
Fleetwings, Inc.

WELDED JOINTS in aircraft tubing and sheet are generally designed so that most of the load or all of the load is carried in shear. The formula for determining allowable load, as given by Army, Navy and Commercial specification ANC-5 is:

$$P = L\,t\,f_s$$

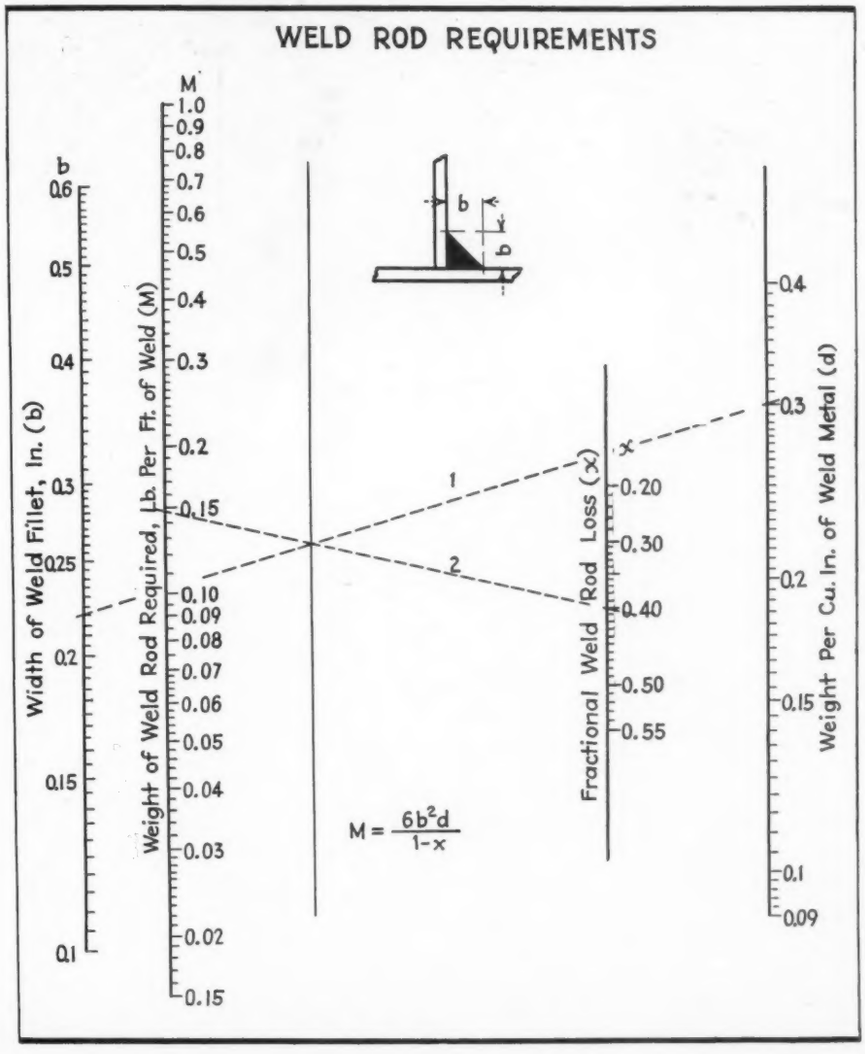
where P = allowable load in lb.
L = length of weld in in.
t = inches thickness of thinnest material joined by lap or butt welds. In tube assemblies t is the average thickness of weld metal (cannot be assumed greater than 1.25 times thickness of welded stock).
S = ultimate tensile strength, lb. per sq. in.
f_s = constant times ultimate tensile stress, lb. per sq.in.

STEEL	S	f_s
SAE 1025	——	32,000
SAE x 4130, no heat-treat	90,000	43,200
SAE x 4130, heat-treated	90,000 to 150,000	0.48 times heat-treated value
SAE x 4130, heat-treated	Over 150,000	72,000

The nomograph on the next page gives allowable load quickly. An example is shown for the following conditions: $L = 4$ in., $S = 100{,}000$ lb. per sq. in., and $t = 0.250$ in. Line (1) is drawn through 100,000 on S-scale and 0.25 on t-scale and gives intersection 0 on line A-A. Line (2) is drawn through 4 on L-scale and point 0 to allowable load lines and gives $P = 48{,}000$ lb. Gage numbers of tube and sheet are shown for convenience.

Pure tension (butt) welds are permissible using the above formula and allowables provided such welds are designed with a factor of two for non-repetitive loads increasing to a factor of four for highly repetitive and reversing stress, in the opinion of some.

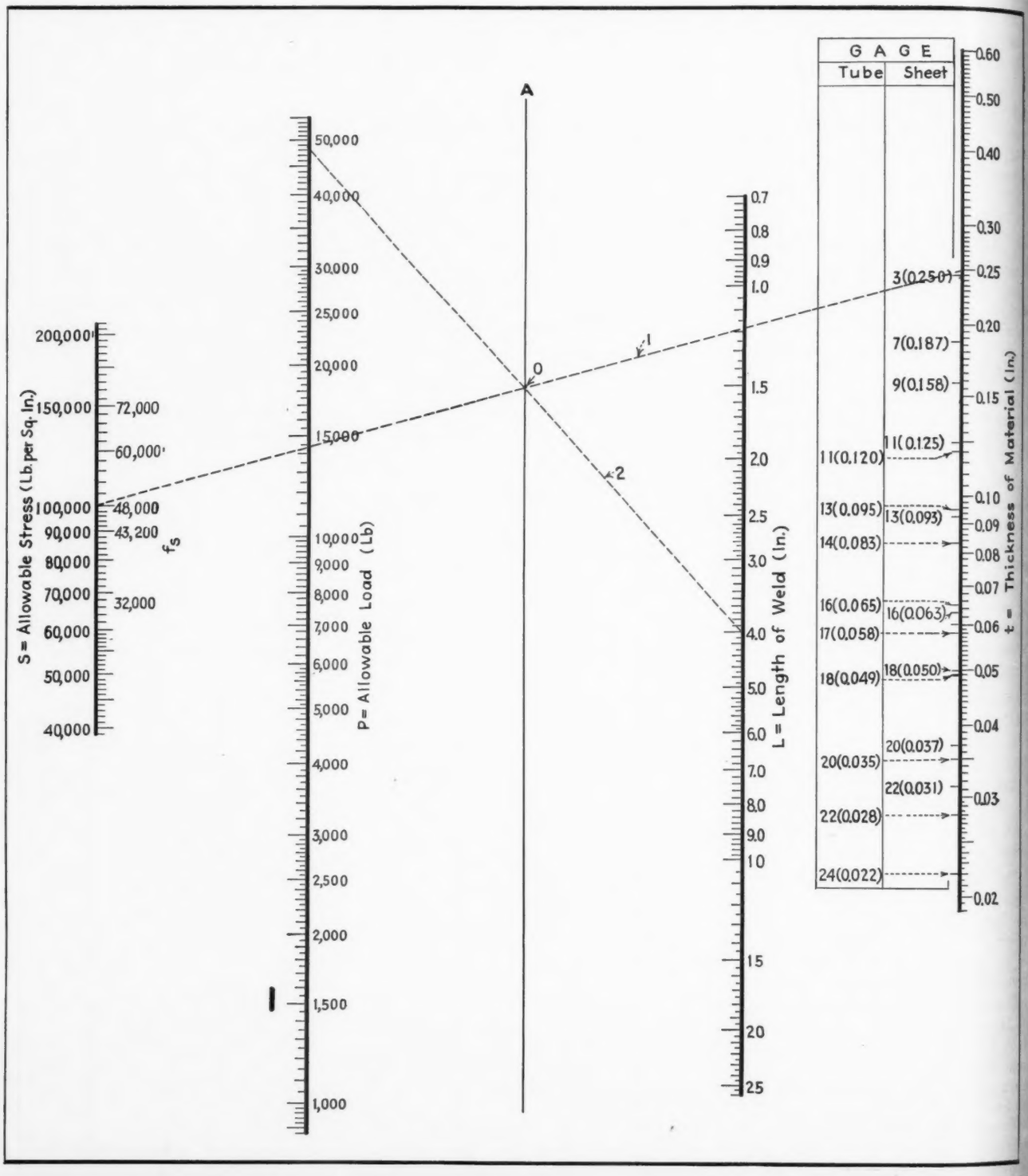
The nomograph on this page enables quick computation of the required weight of welding rod taking into account electrode losses from scrap ends and from spatter and flux coatings, dimensions of weld fillet, and the material used as weld metal. Solution is similar to that for determining length of weld, line (1) being used for multiplying $6b^2$ by d, and line (2) to divide the result by $1 - x$ and give the desired value of M. The terms are defined on the chart.



Strength of Fusion Welds on Aircraft

(Specification ANC-5)

R. R. WIESE
Fleetwings, Inc.



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